JANUARY 1956

Power Engineering

ANNUAL REVIEW 1955

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Circulation of This Issue 36,660

Elliott – playing a vital part in today's power

New Martins Creek Station features outdoor construction, low capacity factor and quick start-up

This new Pennsylvania Power and Light Company Station in eastern Pennsylvania is a model for modern power generation. Its economical outdoor design requires only the principal operating areas to be enclosed. Moderate steam pressures and temperatures, small size condenser and the absence of reheat all are the result of the expected low capacity factor operation. In addition, the initial 132,500-kw unit is designed and instrumented so that it may be shut down at night or over weekends, yet started up again quickly.

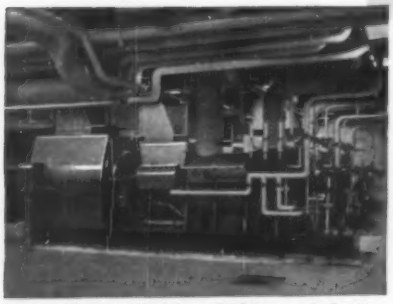
Elliott equipment including large deaerating feedwater heaters, evaporator preheaters, strainers, and the electric motors, 1½ to 2500 hp, which drive important station auxiliaries, plays a vital part in the efficient operation of the station.

For descriptive literature on up-to-date, cost-saving steam and electric equipment, write Elliott Company, Jeannette, Pa.

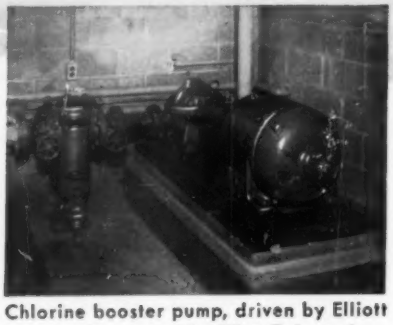
ELLIOTT Company

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS

QS-2



Three Elliott 2500-hp, 3600-rpm induction motors driving boiler-feed pumps.

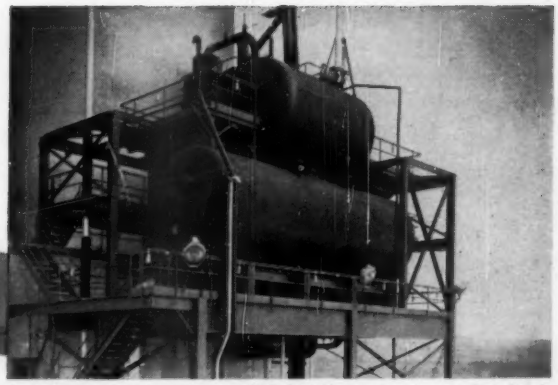


Chlorine booster pump, driven by Elliott motor and protected by Elliott Twin strainer.

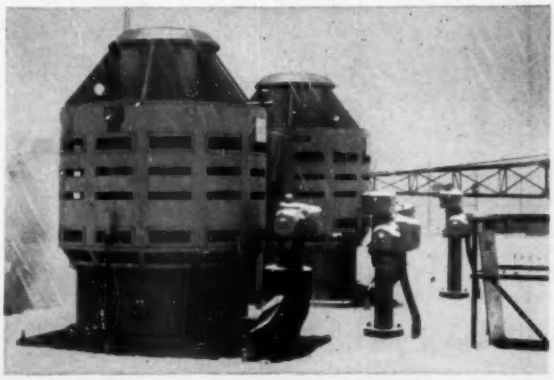
Elliott raw water strainer and two Elliott C-W motors driving pumps.

expansion . . .

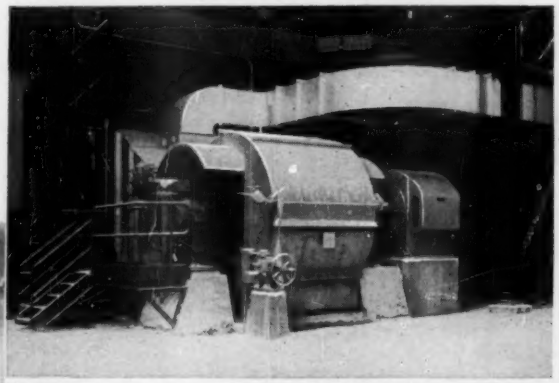
Unit No. 1 of the new Martins Creek Steam Electric Station is operating, with duplicate unit under construction.



A close-up of the Elliott 1,400,000-lb-per-hr deaerating feed-water heater, serving the first unit.

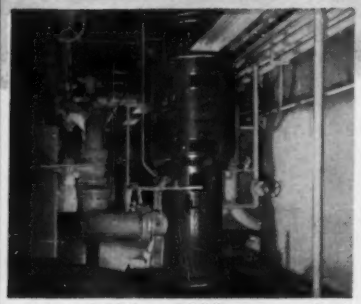


Two Elliott 500-hp, 440-rpm vertical weather-protected motors driving circulating water pumps during snowstorms.

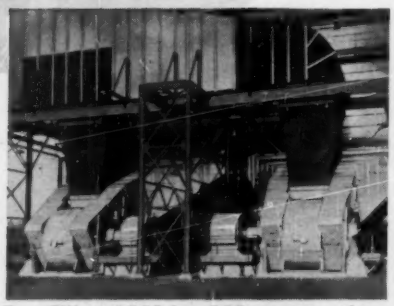


The snow doesn't bother this Elliott 700-hp, 1200-rpm, weather-protected motor driving forced-draft fan.

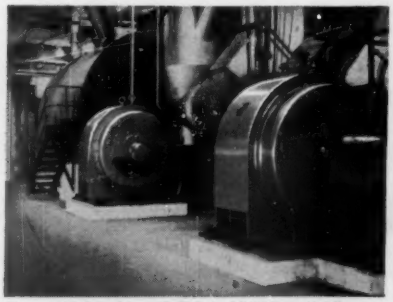
• TURBOCHARGERS • TUBE CLEANERS • STRAINERS



Elliott 350-hp, 1200-rpm vertical motors drive condenser hotwell pumps.



Two Elliott 1250-hp, 900-rpm, weather-protected motors driving induced-draft fans.



Two of the four Elliott 600-hp, 360-rpm motors which drive pulverizer mills.

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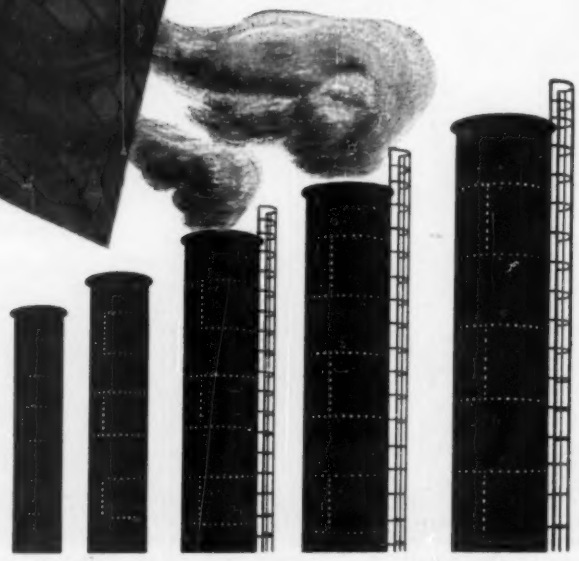
Whether heat is at work . . . or on its way up the stack — every BTU you generate costs you money. Heat recovery, therefore, is dollar recovery — *in any size boiler.*

Now with the Package Ljungstrom® Air Preheater, even boilers as small as 25,000 pounds of steam per hour can operate at fuel efficiencies never before practicable. Compact and self-contained, the unit operates the same as the large Ljungstroms so widely used in large industrial installations — waste heat is absorbed from flue gas by a rotating surface . . . transferred to incoming combustion air . . . and funneled back to the furnace — reducing your fuel costs 1% for every 45-50°F of preheat.

Find out how you can save with the Package Ljungstrom Air Preheater. Write to The Air Preheater Corporation.



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The Package Ljungstrom Air Preheater

- **Reduces fuel consumption . . . permits use of lower-grade fuels**
- **Increases boiler output and reliability**
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- **Easy, fast to clean and maintain**
- **Comes *fully assembled — ready to be installed.***

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PUBLISHED SINCE 1896 FOR POWER ENGINEERS IN PRIVATE AND PUBLIC UTILITIES AND INDUSTRIAL PLANTS

ENGINEERS' PREVIEW

AUTOMATION MUST play a larger and larger role in industry if the American people are to keep on raising their living standards and gaining more leisure hours. Explaining that need, Henry F. Dever, president of the Brown Instruments Division of Minneapolis-Honeywell Regulator Co., cited productivity-per-worker figures in relation to the required "gross national product."

By 1975, he said, experts say our "GNP" will have to be around $858,000,000,000 if our standard of living is to continue rising at the rate it has for the last 15 years. This can be done if the predicted force of 84,000,000 workers each accounts for an expected $10,150 worth of goods annually, he added. However, that would mean we'd all still be working the 40-hour week, Dever said.

So, if Americans are going to have all these goods, and still gain the additional leisure time of something like a 32-hour week, automation or something as good — for raising individual productivity — will have to be part of the scheme of things.

. . .

A. M. KOHLER, vice president of The Babcock & Wilcox Co. and head of its Refractories Division, retired from the company effective August 1. Active charge of the Refractories Division has become the responsibility of J. E. Brinckerhoff as manager.

. . .

FOR OUTSTANDING contributions to industrial peace, Fluor Corporation of Los Angeles has been awarded the annual Father Coogan Labor-Management Award. The honor is given annually to an industrial firm and to affiliated labor groups which have achieved signal labor-management relationships throughout the year. Along with Fluor, 29 international unions of the Los Angeles Building Trades Council, American Federation of Labor, were honored.

PROMOTION of Frank E. Sullivan to the position of Chief Engineer-Industrial Processes for The De Laval Separator Company was recently announced by Walter A. Scott, director of engineering, for the company.

Mr. Sullivan, a native of Staten Island, has been with De Laval since 1950 after several years of chemical engineering experience in vegetable oil refining work with Lever Brothers Co. and E. F. Drew and Co., as well as U. S. Gypsum Co.

He is a graduate of Pratt Institute and received his bachelor's degree in chemical engineering from New York University and a master's degree in chemical engineering from Stevens Institute. As assistant professor of chemistry, he also taught for short periods at Wagner College and at the University of Florida.

. . .

NINTH ANNUAL CONFERENCE for Protective Relay Engineers will be held April 23–25, 1956, at the Department of Electrical Engineering, A & M College of Texas, College Station, Texas. For further information write L. M. Haupt, Conference Chairman.

. . .

HEATING and Cooling Coil Manufacturers' Association announces the adoption of test procedures for heating and cooling coils. Test methods for steam and hot water heating coils and chilled water and volatile refrigerant cooling coils are included in this new Code. Copies of HCCMA Bulletin No. 202 Stand-

POWER ENGINEERING 1955 YEARLY INDEX

IN THIS issue are bound the 1955 alphabetical and subject indexes of POWER ENGINEERING.

However, for those libraries and individuals who wish to bind the index with the 1955 volume, separate copies of the index are available. If you want such a separate copy, write the Editor.

ard Methods of Testing and Rating Forced-Circulating Air-Cooling and Air-Heating Coils, which contain this new Code, can be obtained from the Heating and Cooling Coil Manufacturers' Association, 2159 Guardian Building, Detroit 26, Michigan.

• • •

AS of December 2, 1955, new mailing address for West Penn Power Co. is Cabin Hill, Greensburg, Penna. New Phone Number: Greensburg 8300.

• • •

TWO SOURCE-OF-FACTS reports on science, Scientific Personnel Resources and Federal Funds for Science, have been issued recently by the National Science Foundation under its continuing program of surveying scientific activities in the United States. Scientific Personnel Resources is a summary of data on the supply, utilization and training of scientists and engineers. Federal Funds for Science is the fourth report of its kind issued by the Foundation designed to provide uniform and accurate data on funds made available by agencies of the Federal Government in support of scientific research and development. Copies may be obtained from the Superintendent of Documents, Washington 25, D. C. for 50 cents and 30 cents, respectively.

• • •

HUNDRED YEARS of the world's accumulated experimental data on the thermodynamic properties of pure gases and liquids have been condensed into a hundred pages of the latest published report of the University of Wisconsin's Engineering Experiment Station. The condensation was made possible by extending the theory of corresponding states to include a third variable, the critical compressibility factor, in addition to reduced pressure and reduced temperature.

The new condensation, completed in the UW chemical engineering department, is based upon the behavior of 82 compounds of wide range in composition representing most compounds for which such data have been experimentally determined. The tables have now been extended to include the properties of liquids as well as gases in the same tables and charts in the new publication. For more data on this report, write University of Wisconsin News Service, Madison 6, Wisc.

"Completely automatic, my foot—how about that?"

• • •

VIRGINIA Electric and Power Company has just retained Stone & Webster Engineering Corporation to design and construct a new 165,000 kw addition to the Bremo power station at Bremo Bluff, Virginia, which will bring the station's capability up to 265,000 kw. Cost of the new extension is estimated at $22,000,000, with May, 1958, the anticipated date of operation.

The Bremo plant, which represented an outstanding design at that time, first went into operation in 1931 with two 15,000-kw units. These were later augmented by a 66,000-kw., 1200-psi, 950-F unit installed by Stone & Webster in 1950. Although the original ultimate capacity was anticipated to be 150,000 kw., the new unit will, with its 165,000-kw capability, nearly triple the plant's former capacity. The new unit is the second one of 165,000-kw capacity to be installed by Stone & Webster Engineering Corporation for the Virginia Electric and Power Company system, the other now being installed at the Yorktown plant.

In 1931 an ultimate station capacity at Bremo of 265,000 kw could not have been planned because the 525 psi, 825 F straight regenerative cycle required 28,500 gpm of circulating water for 15 mw or 1.9 gpm per kw, whereas now it is possible to obtain about four times as much power with the same amount of circulating water.

COMMONWEALTH Edison Company has bolstered its capacity for the coming heavy winter load with two big generating units.

One of the units is a new 207,000-kw machine which has just gone into operation at the State Line Station. The other is a 160,000-kw unit which has been restored to service at Ridgeland Station after having been shut down for 11 months due to damage caused by a shaft explosion last December.

• • •

JOHN I. YELLOTT, for the past 10 years director of research for the Locomotive Development Committee of Bituminous Coal Research, Inc. of New York, has been named an assistant director of Stanford Research Institute. He will be heading the development of the Institute's solar energy research program in coöperation with the Association for Applied Solar Energy and will be located in Phoenix, Ariz.

A native of Maryland, Mr. Yellott has bachelor's and master's degrees in mechanical engineering from the Johns Hopkins University.

During 12 years in engineering education and industrial research he taught at the University of Rochester, Stevens Institute of Technology and Illinois Institute of Technology. At the latter institution he was professor and head of mechanical engineering and director of the Institute of Gas Technology.

While with Bituminous Coal Research, he originated a program for developing coal preparation, combustion and ash separation equipment for the open cycle gas turbine. In this connection he supervised research and development programs at Armour Research Foundation, Institute of Gas Technology, Battelle Memorial Institute, Purdue University and Southern Research Institute.

More recently he carried the research results into full scale equipment testing by Northrop Aircraft Co. at Fontana, Calif., and American Locomotive Co. at Dunkirk, N. Y. The latest phase of the program was testing of locomotive-type gas turbine power plants on a stationary test bed at Dunkirk.

DETROIT ROTOSTOKERS SATISFY

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This article should interest you.

It tells how the Chesterfield Richmond plant was modernized. A Detroit RotoStoker fired Babcock and Wilcox Integral-Furnace boiler increased the steam-coal rate from 7.6 to 11.7.

Detroit RotoStokers will save you money. Contact our nearest district office or your consulting engineer.

BOILER PLANT MODERNIZED

"They Satisfy"

Detroit RotoStoker at Liggett & Myers Tobacco Company Richmond, Virginia Plant

•

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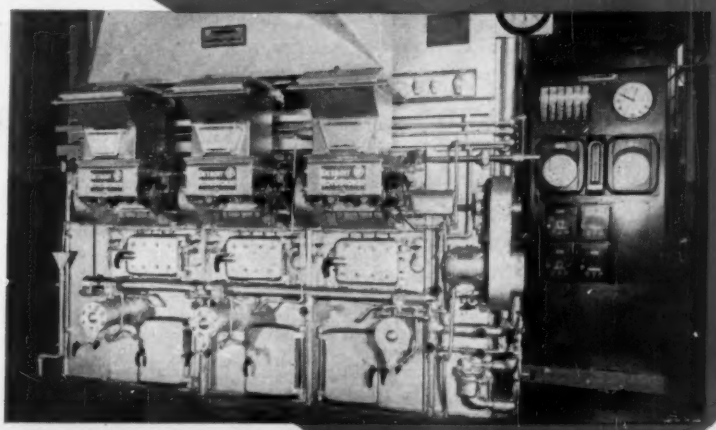

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WHAT THEY TELL US

CARL BLANTON of Salt River Power Co., Mesa, Arizona, recently gave us a good illustration of how carefully readers read POWER ENGINEERING. He wrote

> On page 68 of POWER ENGINEERING, August 1955 issue, you have a picture showing what its builders claim will be "the best looking electric generating plant in America."
>
> I was curious to know if you have ever seen the Salt River Power Company's Kyrene Steam Electric Generating Plant. It certainly is nice looking, and surrounding the plant are beautiful farms.
>
> Here in Arizona the farmers grow crops continually, therefore everything is always pretty and green around this giant power plant that has an output of 100,000 kw. We are all proud of the Kyrene Steam Electric Generating Plant.
>
> Also, I want to congratulate you on publishing such a fine magazine as POWER ENGINEERING.

The photograph will be featured in our News Reel pages in the next issue. He suggested that we write John Rich, superintendent of Steam Plants, for a photograph of the plant, which Mr. Rich in turn sent to us at once. The picture is featured on our News Reel pages, this issue, also a drawing of the same organization's proposed Agua Fria station.

H. D. HEWES, Technical Librarian, Maryland Casualty Company, inquired

> Will you grant us the privilege of reprinting the two articles on pages 80–82, 88–89 of the October 1955 issue of POWER ENGINEERING.
>
> Also, will you please inform us the price for 200 copies of The Gas Turbine Primer from POWER ENGINEERING Handbook on pages 96–100 of the October 1955 issue?
>
> We desire these for distribution among our inspectors.

It was a pleasure to grant permission to reprint Maurice Hartley's article, What Makes an Ultrasonic Machine Tool Work? We also told Mr. Hewes that the pages in our October issue containing the Gas Turbine Primer constituted only the first installment. A second installment appeared in November and the concluding installment was published in the December issue.

We may have reprints made of this series, so please let us know if you wish to order extra sets.

ONE of our readers in Brooklyn, N. Y., commented

> Your August 1954 issue contained an article, Can We Afford to De-Salt Sea Water, in which a new process known as electrodialysis was briefly described.
>
> Do you know where I can obtain more complete information on the subject of electrodialysis?

The book, Fresh Water from the Ocean, by Ellis, was given as one source of data, and Ionics, Incorporated of Cambridge, Mass., as another. Ionics is working on a prime contract for the Department of the Interior and has several working models in existence. The Brooklyn Polytechnic Institute also is charged with the development of the basic theory of ion exchange membranes.

David S. Jenkins, Director of the Saline Water Conversion Program, Department of the Interior, Washington, D. C., is coördinating all this research.

EDITOR KRAMER is now writing a 1200 word review on the year's developments in the field of power industry for The American Peoples Encyclopedia Yearbook — Events and Personalities of the Year. He is also doing an article for the same publication on the non-power technological developments in atomic energy during 1955.

REPLYING TO Ralph Reid, Spaulding Pulp and Paper Company, concerning the effect of radioactivity on the rate of chemical reaction, Editor Kramer wrote

> Radiation chemistry is an extremely complex and still not fully understood phenomenon and it involves both atomic and nuclear processes. By atomic processes, I mean chemical reactions that have to do only with the changes in the energy states and the configuration of the external electron of the atoms. Under intense neutron radiation, for example, isotopic changes occur within the nuclei of atoms which, in turn, affect both the configuration and the energy states of the external electron.
>
> Hence, such radiation may accelerate chemical reaction, and they may bring about chemical reactions at ordinary temperatures and pressures that otherwise can be brought about only by the use of very high temperatures and pressures.
>
> A case in point, is the gamma ray initiated polymerization of styrene at room temperatures and at moderate pressures. Heretofore, such polymerization was brought about at temperatures of around 1000 F and at pressures in the neighborhood of 25,000 or 30,000 lb psi.
>
> Considerable work on this type of reaction has been done at the Brookhaven National Laboratory and also at the University of Michigan.

OUR EDITORIAL DIRECTOR, Richard H. Morris, was elected president of the Society of Business Magazine Editors at the November 1955 meeting. Mr. Morris succeeds Frank Tighe, editor of *Motor Age*.

Richard Morris

Other officers elected were Eldridge Peterson, *Printers' Ink*, first vice-president; Norman C. Firth, *Dun's Review and Modern Industry*, 2nd vice-president; William A. Phair, *Hardware Age*, secretary-treasurer.

Paul Wooton was elected to another 5-year term as chairman of the executive committee.

A $500 educational grant named after Mr. Wooton, long-time Washington newspaper and business paper correspondent, has been inaugurated by the Society. The privilege of presenting this grant to a college student or graduate student studying business journalism goes to Henry Ford II, president of the Ford Motor Co. who was chosen by the Society to receive its first annual Voice of Business Award.

REPORTS INDICATE that various engineering societies have some literature available for the high school student and college freshman describing engineering in general, but that very little has been prepared to explain specifically what *power engineering* is, why a career in power engineering should interest a young man, and what he needs to learn and do to get into it.

Members of our editorial staff have discussed with student counsellors, in both high schools and universities, the possibilities of writing a booklet for the purpose. Everyone has been enthusiastic and believes this type of literature is urgently needed.

Executive Editor Earle is already outlining plans to go ahead with this project just as rapidly as possible. If you have any comments that would help us, please send them.

higher loads...
economy fuels...
new
engine designs...

there's one answer for all three of these lubrication problems—

Demands upon the lubricant in stationary industrial engines are increasing. More severe operating conditions caused by heavier loads, new engine designs and the use of economy fuels pose difficult lubrication problems not met by conventional oils. Standard Oil Company introduces a lubricant specifically designed to meet these problems—STANODIESEL Oil M.

STANODIESEL OIL M

STANODIESEL Oil M meets or exceeds the requirements of a lubricant for stationary industrial engines. Here's why:

STANODIESEL Oil M is refined from the highest quality base stock. It has superior stability.

Special additives are blended with this STANODIESEL Oil M base stock. An oxidation inhibitor prevents unwanted increases in oil viscosity and prevents corrosion of bearings. The action of detergent-dispersant additives keeps crankcase, pistons, cylinder walls and other parts clean. Contaminants are kept in suspension and are prevented from depositing. An anti-foam agent makes this oil suitable for use in hydraulic governors. A wetting agent increases the oil's ability to reach and maintain a film on such highly stressed parts as cams and cam followers.

Use of STANODIESEL Oil M means this: less engine deposits, less ring and cylinder wear. Less spark plug fouling when used in gas engines. Eliminates fuel injector and pump sticking caused by deposits on the injector barrel and plunger when fuel and lubricating oil commingle.

You need to know about STANODIESEL Oil M. In the Midwest, call your nearby Standard Oil lubrication specialist. You will receive the information promptly. Or write Standard Oil Company, 910 South Michigan Avenue, Chicago 80, Illinois.

STANDARD

STANDARD OIL COMPANY (Indiana)

"this is

● Engineers tell us Yarway Remote Liquid Level Indicators are the most dependable boiler insurance they can have.

Instant . . . accurate . . . brilliant . . . continuous readings of boiler water level are seen on the panel or wherever you wish in your plant. You know the readings are right because they are controlled by the boiler water itself . . . by the pressure differential between a constant head of water and the varying head in the boiler drum. *Indicating mechanism is never under pressure.*

Yarway Indicators may be equipped with a Yarway Control Unit that operates Remote Hi-Lo-Alarm signal lights or horns. For a 24-hour record of boiler water levels, use the Yarway Hi-Lo-Graph Recorder.

On the boiler drum itself you'll want Yarway Water Gages . . . and these "bright as a star" gage readings can now be televised with a Yarway—RCA Television chain.

From drum to panel and at all remote locations, Yarway equipment gives you the safest boiler protection you can buy . . . proved beyond doubt in thousands of power plants.

Write for the specific bulletins you want.

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YARWAY

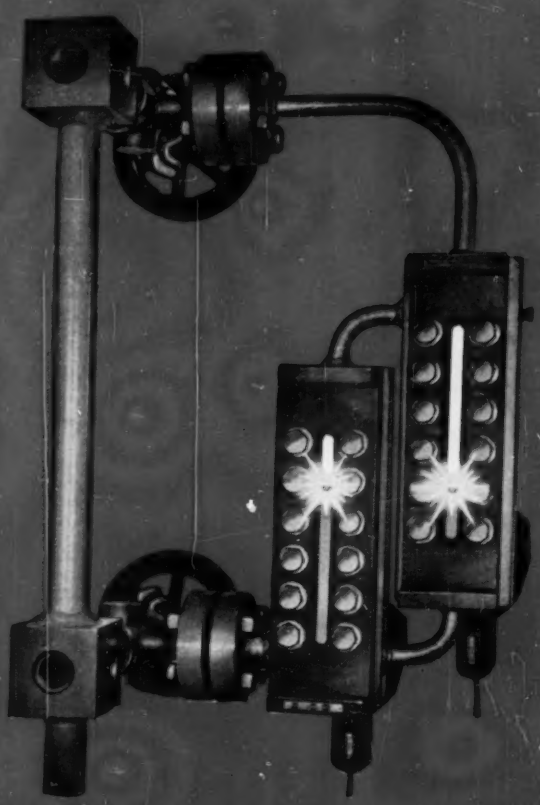
NEW! WIDER VISION!

Clear, brilliant readings from any angle, are possible with the new "wide vision" face on the Yarway Remote Liquid Level Indicator. Pointer is always visible, even at extreme high and low water levels.

The Yarway Indicator is manometric type with automatic temperature compensation, as approved for use under the ruling of A.S.M.E. Boiler Code Committee in Case #1155.

Described in Yarway Bulletin WG-1824.

good boiler insurance!"



YARWAY WATER GAGES

Flat glass, high pressure type shown, features new separated-design insert and Type "M" illumination that causes water level meniscus to "shine like a star". Described in Yarway Bulletin WG-1812.

YARWAY REMOTE SIGNAL ALARMS

Lights on horns, operated by Control Unit on Yarway Indicator, give instant warning of any serious deviation from normal water level. Can be located anywhere in plant. Described in Yarway Bulletin WG-1824.

YARWAY HI-LO-GRAPH RECORDER

Gives a continuous 24-hour record of liquid levels. Actuating mechanism is same as in Yarway Indicator. Used both for indicating and recording. Described in Yarway Bulletin WG-1830.

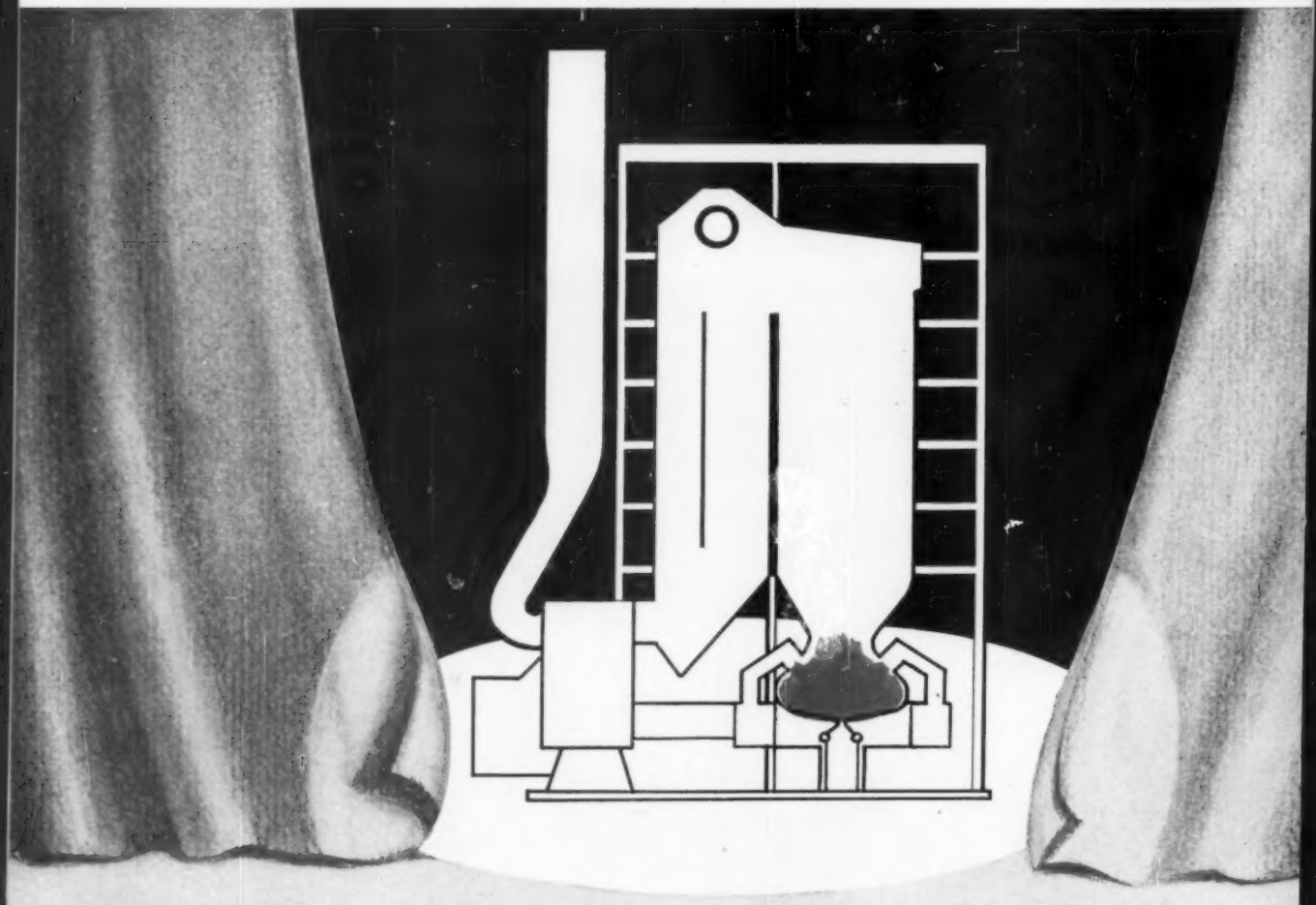
YARWAY RCA TELEVISION

Simplified system consists of compact camera and panel-mounted monitor. Clear, bright image of water level gage anywhere in the plant.
Described in Yarway Bulletin WG-1813.

steam plant equipment

BLOW-OFF VALVES
WATER COLUMNS AND GAGES
LIQUID LEVEL INDICATORS
EXPANSION JOINTS
STEAM TRAPS
STRAINERS
SPRAY NOZZLES
DIGESTER VALVES

For more data circle 505 on Post Card



Efficiently uses a wide range of coals . . . oil

With these outstanding advantages:

- No slag blowers required
- Higher efficiency — lower carbon loss
- No stratification of furnace gases
- All burners on one level
- No flyash disposal problem
- The same temperature of gases leaving furnace with any fuel
- No conversion of pressure parts required for change of fuel
- Lower overall height

...gas...lignite...delayed coke...fluid coke

A survey of your plant by a consulting engineer could show ways of making surprising savings in your power costs.

RILEY
Stoker Corporation
WORCESTER, MASSACHUSETTS

Sales Offices: Worcester, New York, Philadelphia, Buffalo, Washington, Pittsburgh, Cleveland, Detroit, Chicago, Cincinnati, Charlotte, New Orleans, Atlanta, St. Louis, Kansas City, St. Paul, Houston, Denver, Salt Lake City, Los Angeles, San Francisco, Portland, Seattle.

UNITS WITH RILEY TURBO FURNACES ARE DESIGNED FOR ANY CAPACITY, PRESSURE, TEMPERATURE

A Few Turbo Furnace Units

ST. CROIX PAPER CO.
One 175,000 lb./hr. Unit, 750 psig, 725F.

CARBIDE & CARBON CHEMICALS CO.
One 175,000 lbs./hr. Unit, 450 psig, 515F.
One 289,000 lbs./hr. Unit, 650 psig, 660F.

DELAWARE POWER & LIGHT CO.
Three 500,000 lbs./hr. Units, 1425 psig, 950F.

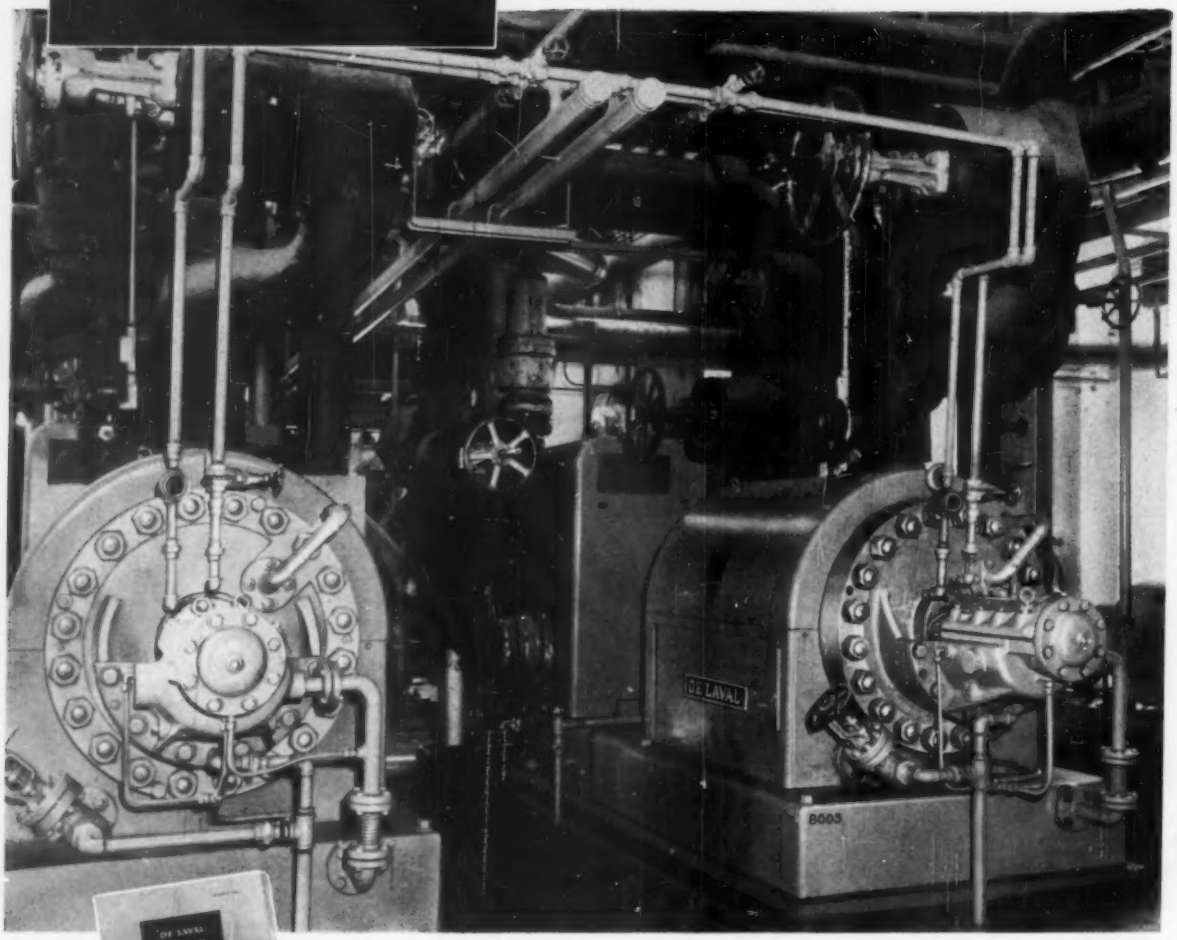
TEXAS ELECTRIC SERVICE CO.
One 825,000 lbs./hr. Reheat Unit, 1750 psig, 1005/1005F.

LOUISIANA POWER & LIGHT CO.
One 1,550,000 lbs./hr. Reheat Unit, 2125 psig, 1005/1005F.

For more data circle 506 on Post Card

DE LAVAL
BARREL TYPE BOILER FEED PUMPS

give dependable service at Gaylord Container



Bulletin contains helpful data

Bulletin 1506 on the De Laval barrel type boiler feed pump covers all major design points... has cross-section cutaway illustration for easy reference. Write for your copy.

Here's additional proof of De Laval reliability on the line in the Bogalusa, La. plant of the Gaylord Container Corporation. These two De Laval barrel type boiler feed pumps are both driven by De Laval MCP turbines operating at 850 psi, with steam temperature at 825 F.

• De Laval barrel type boiler feed pumps are widely used by industrial plants and public utilities. They operate at pressures up to 5,500 psi. These units offer many important design advantages, such as double volute diaphragm, individual diaphragm bolting, positive sealing between suction and discharge chamber and bare shaft construction. Their dependability is proven by year-in, year-out service.

DE LAVAL *Boiler Feed Pumps*

DE LAVAL STEAM TURBINE COMPANY

816 Nottingham Way, Trenton 2, New Jersey

DL 320

For more data circle 507 on Post Card

Call on ALLIS-CHALMERS for Water Conditioning

How Zeolite System at Public Service Company of Colorado

"Irons Out"

Water Irregularities Caused by Fluctuating Loads

DENVER'S UNUSUAL CLIMATE causes unusual water conditioning problems at Public Service Company of Colorado's Zuni Station. Steam from this station is used to heat downtown Denver buildings. Denver's balmy midday climate — except in the two cold months of the year—is the cause of troublesome load fluctuations.

The lime-soda-phosphate system installed in this plant by Allis-Chalmers in 1949 was one of the most modern in the country at the time. It is ideal for extremely high loads in the morning and evening, but requires careful adjustment to handle the low loads around noon.

Public Service of Colorado has decided to modernize to take advantage of developments in "hot lime–hot zeolite" systems since the original installation. The zeolite part of the system acts as its own corrective when loads drop, "ironing out" hardness irregularities in the lime effluent and eliminating need for manual adjustments. The new system will provide more consistent operation and lower hardness. The only chemicals needed are lime and salt, holding operating costs to a minimum.

The changeover, being handled completely by Allis-Chalmers, consists of adding zeolite softeners to the original equipment furnished by A-C.

Next time you have a water problem — or want to consider modernization — take advantage of Allis-Chalmers water conditioning experience. For information, call the A-C office nearest you or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

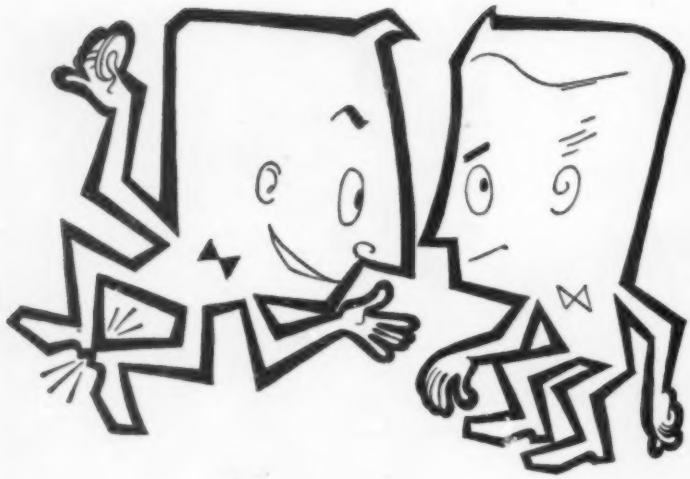
ALLIS-CHALMERS

WATER CONDITIONING—CHEMICALS, EQUIPMENT, SERVICE—FOR OVER 25 YEARS

A-C ALLIS-CHALMERS

A-4846

For more data circle 508 on Post Card

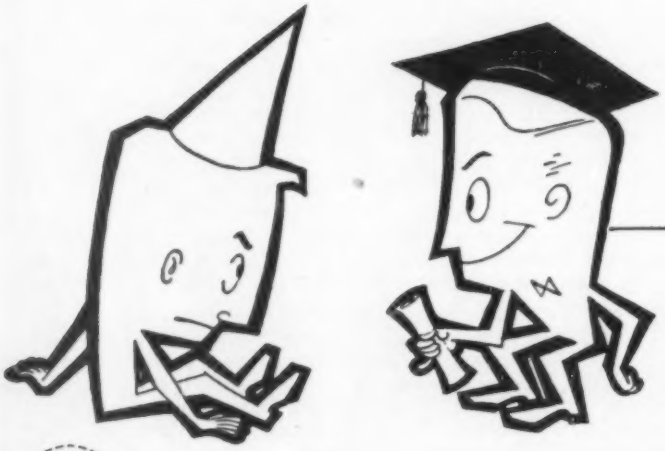


Look! I can buy coal for much less a ton than you're paying.

I used to buy that coal too, but it costs more per million BTU's with a whole lot more in hidden costs.

What do you mean by "hidden costs"?

That coal you're talking about is high in ash. So we were buying ashes at the coal price, paying freight on them from the mine, then paying to have them hauled away. Your "cheaper" coal clinkers; it smokes; it fouls the tubes. That means higher labor costs and higher maintenance. Now I pay more per ton and save thousands of dollars a year.



Coals produced on the C&O are tops in quality.

A C&O combustion engineer showed me why this grade of coal would work best in our type of installation and our experience has shown he was right. You'd better get some expert advice. It can save you money, too.

P.S.

There's a lot more to buying coal than the cost per ton. Why not contact coal producers on the C&O to solve your particular fuel requirements, or write to: R. C. Riedinger, General Coal Traffic Manager, Chesapeake and Ohio Railway Company, Terminal Tower, Cleveland 1, Ohio.

Chesapeake and Ohio Railway

WORLD'S LARGEST CARRIER OF BITUMINOUS COAL

For more data circle 509 on Post Card

A good start is a sure way
to maintain highest boiler efficiency

Cleaver-Brooks factory-trained servicemen instruct your operating personnel and adjust your boiler for peak efficiency. This service doesn't cost you a cent.

OTTO POLZIN is a typical Cleaver-Brooks factory-trained serviceman. He is shown on the job at Oilgear Co., Milwaukee, where he has just given two 125-hp Cleaver-Brooks boilers an initial start. Norbert Husting and Gordon Knischke of Oilgear are getting all the details on boiler operation and maintenance, including boiler blow-down procedure and tube cleaning.

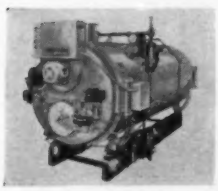
While on his "starting service call", Otto covered all of 32 items on his check list — such as the entire lubrication system, a CO_2 reading, inspected and cleaned relay points. In short, he *personally* made sure both boilers were "tuned" to perfection!

Cleaver-Brooks service is nationwide

This service is "standard practice" everytime a Cleaver-Brooks boiler is put into operation. And, as thousands of owners know, a phone call to your local Cleaver-Brooks representative brings this and other specialized services when needed.

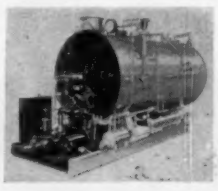
Factory-supervised starting is just one of many advantages of being a Cleaver-Brooks boiler owner. You get the ultimate in modern boiler design: forced draft with four-pass construction, hinged or davited front and rear doors for fast cleaning, 10-second gas or oil interchange — just to name a few features.

Get the full story on the complete line — sizes from 15 to 600 hp; 15 to 250 psi. Call your nearby Cleaver-Brooks representative or write direct. Cleaver-Brooks Company, Dept. A, 310 E. Keefe Ave., Milwaukee 12, Wisconsin, U.S.A. Cable Address: CEEBEEWEST — all codes. Ask for catalog AD-137.



MODEL CB — Most silent-running boiler on the market. Ideal for schools, hospitals. Sizes: 15 to 150 hp.

MODEL LR — Standard of the industry for steam or hot water service in heating or processing applications. Sizes: 200 to 600 hp.



Cleaver-Brooks®

TWENTY-FIVE YEARS OF LEADERSHIP BY THE ORIGINATORS OF THE SELF-CONTAINED BOILER

For more data circle 510 on Post Card

CONTROL OF OVER 130 BOILER FUNCTIONS
at Ridgeland Station, Chicago is centralized on these Republic electronic benchboards.

Controlling Combustion Electronically at World's Largest Cyclone-Fired Plant

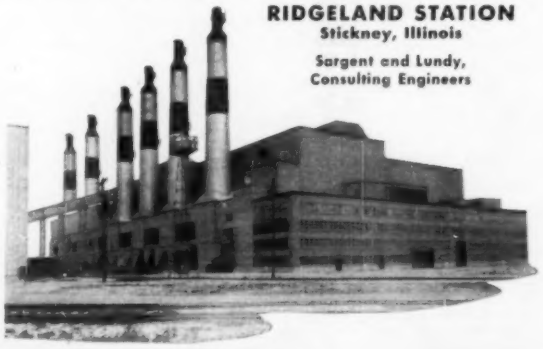
Commonwealth Edison's 640,000 KW Ridgeland Station near Chicago is the largest completely cylone-fired power plant in the world. A total of 28 cyclone furnaces fire the plant's six boilers.

To maintain maximum firing efficiency, combustion conditions at each cyclone are individually controlled and integrated with over-all plant operation by a Republic Electronic Combustion Control System. The system provides separate controls for primary air, secondary air, fuel feed and fuel-air ratio at each of the 28 cyclone furnaces in addition to controlling forced and induced draft fans and feedwater pumps on each boiler. All told, there are more than 130 individual controls which are automatically coordinated for continuous proper combustion.

Republic Electronic Controls handle all of these functions without introducing transmission lags, complicated pneumatic-mechanical linkages and inaccuracies due to mechanical inertia into the control system. Integration of control information is greatly simplified by use of electronic circuits. Expensive panel piping is eliminated and control panels are easier to operate. Because transmission of control impulses is electrical, all parts of the control system can respond simultaneously for smooth, coordinated operation of the boilers.

Ridgeland is but one of many modern cyclone-fired power plants that are equipped with Republic Combustion Controls. In fact, more cyclones are controlled by Republic than by any other make of controls.

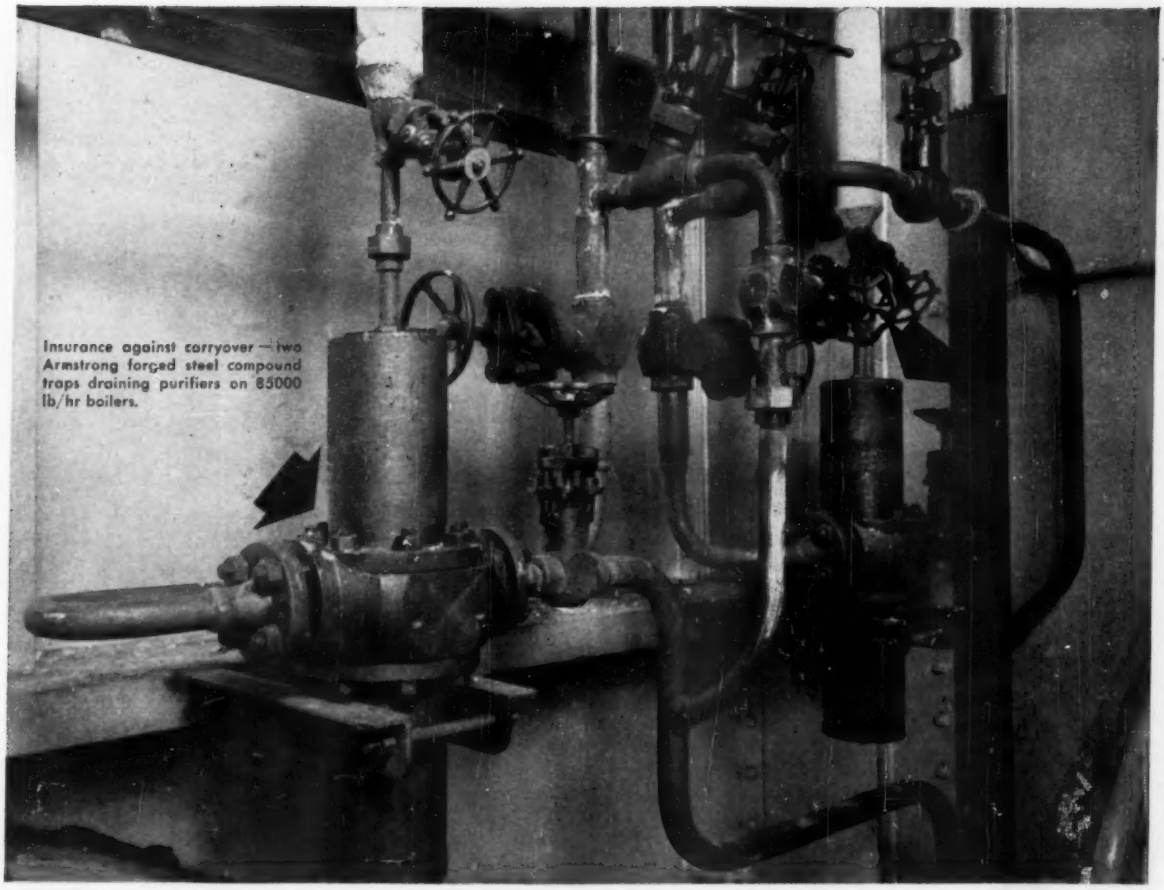
Republic makes a complete line of combustion controls for all types and sizes of boilers, all methods of fuel firing, all load conditions and all arrangements of draft. Write us when your problem is combustion controls.



RIDGELAND STATION
Stickney, Illinois
Sargent and Lundy, Consulting Engineers

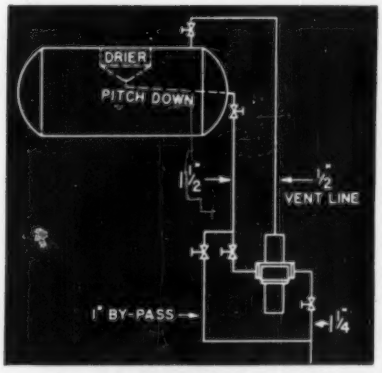
REPUBLIC FLOW METERS CO.
2240 Diversey Parkway, Chicago 47, Illinois

For more data circle 511 on Post Card



Insurance against carryover — two Armstrong forged steel compound traps draining purifiers on 85000 lb/hr boilers.

How to Insure Positive Drainage of Purifiers, Large Separators and Other Big Units . . .



Automatic, dependable drainage of steam drier in industrial power plant with Armstrong compound steam trap.

● When you run up against a carryover or condensate load too large for ordinary traps to handle safely, Armstrong Compound Steam Traps are an ideal answer. They provide automatic, dependable drainage of loads up to 240,000 lbs/hr at 600 lbs. pressure. They have been thoroughly proved in service on purifiers, separators, driers, storage type hot water heaters, evaporators, vacuum pans and other large units.

Exceptionally high capacity in a relatively small trap is accomplished by a large piston-operated discharge valve controlled by a standard Armstrong inverted bucket trap mechanism. Cast semi-steel and forged steel models are available with 1", 2" and 3" pipe connections. Size, price, simplicity of mechanism, quality of materials and ease of installation are all in their favor.

ASK FOR BULLETIN 215

. . . contains complete physical data, prices and installation notes. Call your local Armstrong Representative or write: Armstrong Machine Works, 810 Maple St., Three Rivers, Michigan

STEAM TRAPS FOR EVERY REQUIREMENT

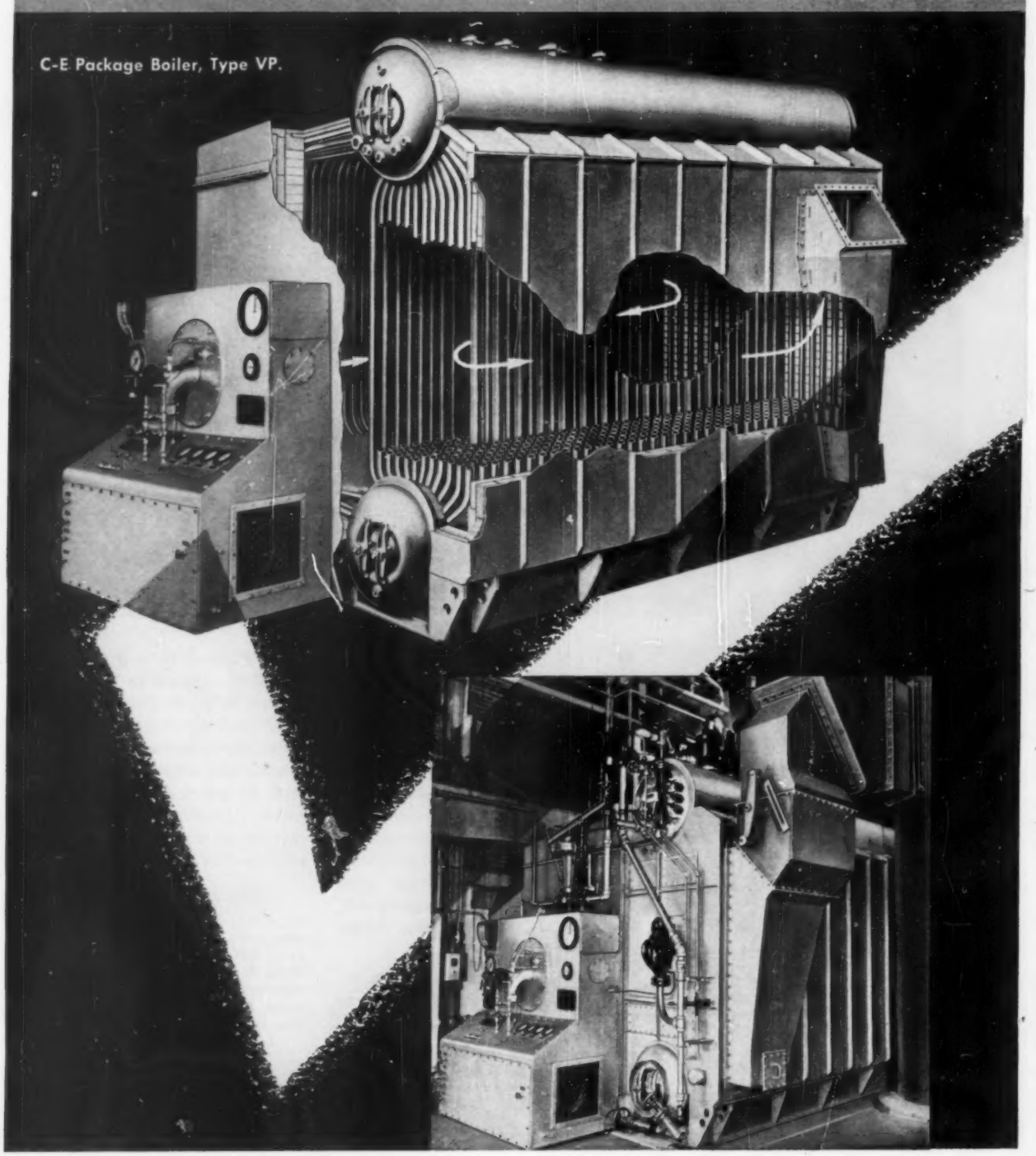
ARMSTRONG

APPLICATION ENGINEERED

STEAM TRAPS

For more data circle 512 on Post Card

BEFORE YOU BUY A PACKAGE BOILER . . .



C-E Package Boiler, Type VP.

CHECK THIS LIST!

	BOILER A		BOILER B		BOILER C	
	Yes	No	Yes	No	Yes	No
Will your boiler be a real "package" type with control panel and all controls mounted integral with the boiler?	☐	☐	☐	☐	☐	☐
Will your package boiler be equipped with drum internals to assure dry steam?	☐	☐	☐	☐	☐	☐
Will its "steam quality" be backed with a guarantee?	☐	☐	☐	☐	☐	☐
Will your boiler have a 30-in. lower drum to provide convenient accessibility?	☐	☐	☐	☐	☐	☐
Will yours be a one-burner boiler, with a simple wiring and control system?	☐	☐	☐	☐	☐	☐
Will your boiler have the largest load swing range available?	☐	☐	☐	☐	☐	☐
Will your boiler be equipped with a quiet centrifugal fan?	☐	☐	☐	☐	☐	☐
Will your furnace be *completely* water-cooled?	☐	☐	☐	☐	☐	☐
Will your furnace have the highest ratio of water cooled surface to furnace volume?	☐	☐	☐	☐	☐	☐

If you are in the market for a package boiler, this check list can provide you with some interesting answers. Of course C-E's Type VP Boiler rates a "yes" answer to every question. In addition it offers many other operational advantages such as simple, effective soot blowing; high heat absorption; low draft loss; no dead gas pockets and simple baffle arrangements.

Little wonder then that VP purchasers range from small companies to some of the largest in the country . . . industrials of all kinds . . . schools and institutions . . . various government agencies . . . including the Atomic Energy Commission. These users are employing VP Boilers for all types of applications — heating, process, and even power generation.

SPECIFICATIONS
of the VP Boiler

Capacity — 4,000 to 40,000 pounds of steam per hour

Pressures — up to 500 pounds per square inch

Fuel — oil or gas

Erection — completely shop-assembled

Foundation — simple concrete slab

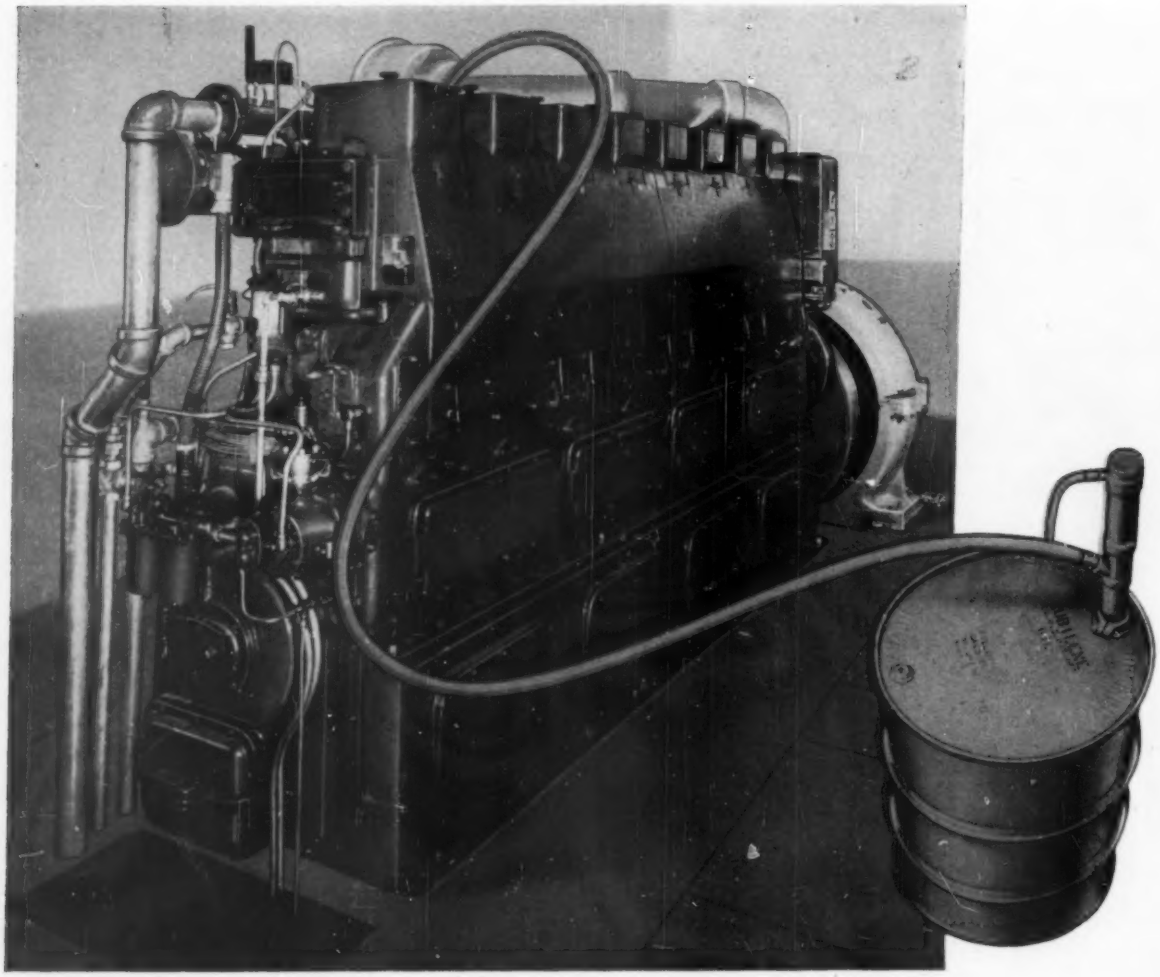
Make sure that you have details of the VP at your fingertips when you are in the market for a boiler of moderate capacity. Ask for the new Catalog VP-118, which contains specifications and general information on dimensions, construction details and controls. B-845

COMBUSTION ENGINEERING

Combustion Engineering Building • 200 Madison Avenue, New York 16, N. Y.

BOILERS, FUEL BURNING & RELATED EQUIPMENT; PULVERIZERS, AIR SEPARATORS & FLASH DRYING SYSTEMS; PRESSURE VESSELS; AUTOMATIC WATER HEATERS; SOIL PIPE

For more data circle 513 on Post Card



Stops Thin-Out!

You can protect your Diesel against wear due to excessive thin-out of the lubricating oil at higher operating temperatures. Switch to Sinclair RUBILENE®, *the high viscosity index oil* proved by over 35 years in a wide variety of Diesel applications. You'll find RUBILENE holds its high film strength and reduces oil consumption . . . gives you better protection of cylinders, pistons, rings and other vital moving parts operating continuously for long periods. Your Diesel logs more full-power hours!

Switch now to RUBILENE. Regardless of the make of your Diesel, there's a member of Sinclair's famous RUBILENE or RUBILENE HD family that meets your needs exactly! Call your local Sinclair Representative or write for free literature to Sinclair Refining Company, Technical Service Division, 600 Fifth Avenue, New York 20, N. Y. *There's no obligation!*

SINCLAIR

RUBILENE OILS

For more data circle 514 on Post Card

Inside story:

Valves may look alike on the surface. Their performance is another story. And the inside story of Powell Valves is that *every* Powell Valve has *Performance Verified.*

X-ray and gamma ray inspection—examining the very structure of the metal itself—are two of the many ways that Powell can make absolutely certain that Powell Valves will give *dependable* flow control.

Every part of every valve must pass rigid inspection. As a final step in manufacture, every Powell Valve is subjected to *an actual line test.* Because of Powell's pains-taking quality control, valve repair is cut to the minimum and plant shut down through valve failure is substantially reduced. Records from refineries, power and industrial plants the world over prove it.

Consult your Powell Valve distributor. If none is near you, we'll be pleased to tell you about our COMPLETE *quality line* which has PERFORMANCE VERIFIED.

The Wm. Powell Company, Cincinnati 22, Ohio . . . 110th YEAR

PERFORMANCE PV VERIFIED

FIG. 19003 WE—900-Pound Steel Pressure Seal Gate Valve.

FIG. 11365 WE—Steel Pressure Seal Horizontal Lift Check Valve for 1500 Pounds W.S.P.

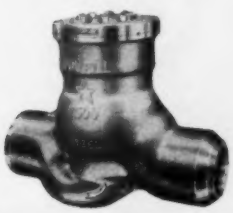


FIG. 3031 WE—Steel Globe Valve for 300 Pounds W.S.P.

POWELL VALVES

BRONZE, IRON, STEEL AND CORROSION RESISTANT VALVES.

For more data circle 515 on Post Card

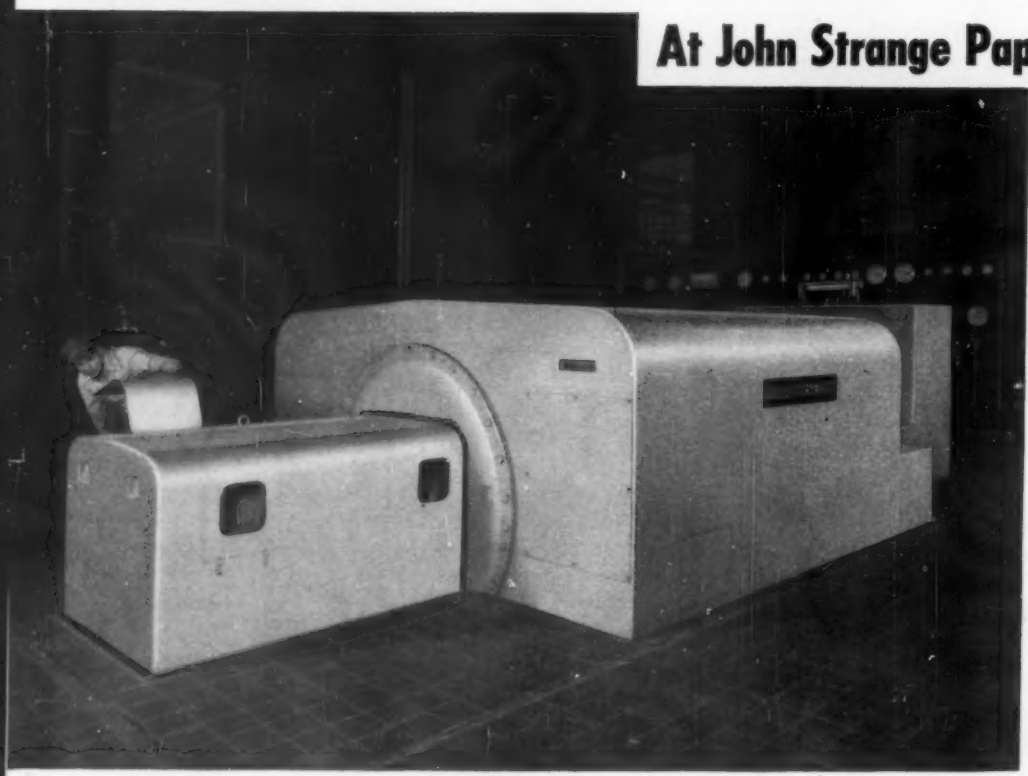
Paper Mills Choose for

WA-Series

STEAM TURBINE GENERATOR UNITS

Produce Economical Plant Power as By-Product from Process Steam

At John Strange Paper Company



MENASHA, WISCONSIN

5000-kw WA-Series unit produces power at 2400/4160 volts as a by-product of 150,000 lb per hour of process steam. Steam conditions at the turbine are 700 psig, 825 F, with 50 psig exhaust.

ALLIS-

Allis-Chalmers Units Power Generation

The paper industry is a good example of many industries across the country that are choosing modern Allis-Chalmers WA-Series steam turbine generating units for plant power generation. Many installations are already operating in NEMA ratings from 2000 to 7500 kw. Recently, the line was extended to 16,500 kw in AIEE-ASME preferred ratings.

WA-Series units are available for condensing or non-condensing service, with or without automatic extraction, providing the kind of advanced design that power producers want. Basic engineering features include labyrinth steam seals throughout, removable external glands, high chrome alloy steel buckets, and a time-proved governing system.

Engineered to Save Installation Costs

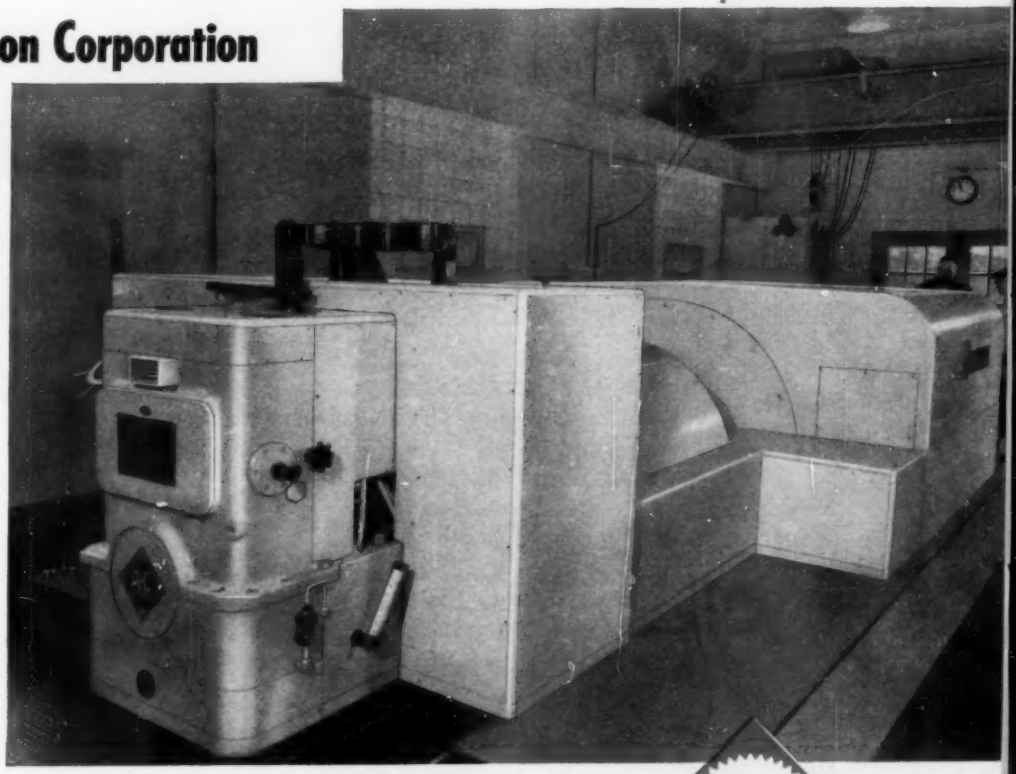
Particular care has been taken to promote ease of installation. Oil piping is above the floor line, eliminating need for trenches in the foundation. Generator gas coolers are located above the floor, eliminating ductwork through the foundation. Much of the work formerly done in the field is now performed in the factory. As a result, both turbine and generator can be shipped assembled ready for immediate installation.

For a detailed story on the advantages you can obtain with Allis-Chalmers steam turbine generating units, call your nearby A-C office, or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin, for Bulletin 03B7654. A-4868

At Marathon Corporation

ROTHSCHILD, WISCONSIN

4000-kw WA-Series unit produces power at 2400/4160 volts as a by-product of approximately 100,000 lb per hour of process steam. Steam conditions at turbine: 600 psig, 825 F, with 40 psig exhaust.



CHALMERS

A-C ALLIS-CHALMERS

For more data circle 516 on Post Card

The Power Plant Engineer Said:
"I WOULDN'T KNOW..."

INQUIRING REPORTER: So you use Nalco System water treatment ... How often are your boilers turbined?

ENGINEER: I wouldn't know—only worked here seven years.*

* You recognize the Engineer's answer as a twist on the old one about *How-often-do-you-get-a-raise-around-here.* Our excuse for bringing it up is that the engineer's answer applies to hundreds of plants using Nalco water treatment. New plants, starting boilers from scratch with Nalco, report years on line, *billions* of pounds of steam generated in boilers that have *never* been turbined... and probably never will be. Older plants, where turbining was as routine as checking the draft gauges, now open boilers only to show the inspectors.

These Nalco *results* can quite possibly be duplicated in your plant, regardless of the kind or severity of your water treatment problems... or the size of your operation. Write or phone, now, for a fast start toward permanent water treatment security.

NATIONAL ALUMINATE CORPORATION

6224 West 66th Place • Chicago 38, Illinois

Telephone: POrtsmouth 7-7240

In Canada: Alchem Limited, Burlington, Ontario

THE *Nalco*® SYSTEM . . . Serving Industry through Practical Applied Science

For more data circle 517 on Post Card

HELPFUL BULLETINS

ELECTRICAL EQUIPMENT

101 Improved Motors — Bulletin N-100-F, 16 pp, describes this company's Series 100 motors and explains why these smaller, lighter motors are cooler running. Design features are illustrated in color and discussed, and dimensional data provided. Booklet stresses advantages in operating efficiency and dependability incorporated in the new NEMA frame sizes and offers information of value in motor selection. Howell Electric Motors Co.

102 Building Block Switchboards — "Switchboards with Basic Circuits," Bulletin GEA-4127B, 40-pp, discusses company's "building block" concept as applied to switchboards. Shows how eight classifications are constructed, operated and tested. A complete discussion of basic circuit specifications in duplex switchboards is included. Bulletin is illustrated with numerous photos and circuit diagrams. General Electric Co.

103 Metal-Clad Switchgear — Advantages offered by this company's indoor and outdoor metal-clad switchgear are explained by photo and text in 28-pp Form 7004-C. Shows construction details of the 7.5 and 15 kv switchgear with drawout air magnetic circuit breakers and provides ratings. Compartment isolation provided, arrangements for control and auxiliary equipment, easy handling, safety devices, design simplicity and other features are covered. Drawings illustrate dimensions. I-T-E Circuit Breaker Co.

104 Fuse Links — Twelve-pp Booklet GEA-6264 on EEI-NEMA standard fuse links covers the use of both fast and slow-melting cable-type links in distribution cutouts with ratings up to 15,000-v. Gives time-current curves and co-ordination tables to help utilities make the changeover to the standard links. Booklet is illustrated with numerous photos, tables, and minimum and maximum time-current graphs. General Electric Co.

MECHANICAL POWER TRANSMISSION

105 Versatile Drive — Bulletin 4400-PRD-229 illustrates the Ampli-Speed magnetic drive for use in both fan-type and constant torque loads. Construction features are shown, and drawings illustrate relationship of drive to its magnetic amplifier control, the driving motor and the driven load. Advantages offered by this drive are listed. Also included are horsepower ratings, speed ranges, dimensions. Electric Machinery Mfg. Co.

106 Variable Speed Drive — Bulletin A-643 features company's line of variable speed drives, describing variable sheaves, companion sheaves, sealed-life "R" and "W" belts, and slide motor bases. Includes specification data, and rating tables. Dodge Mfg. Corp.

107 Flexible Couplings — All metal flexible couplings are presented as to advantages and applications in illustrated Form 82. Photos show several installations. Thomas Flexible Coupling Co.

108 Couplings in Action — Twelve-pp Form 12 contains a number of case histories of power transmission problems solved by this company's Amerigear coupling. They deal with use in heavy mill service, high-speed turbines, hydraulic presses, 'round-the-clock power supply and others. Generously illustrated with photos and drawings, booklet also shows how fully-crowned tooth design contributes to efficiency of the coupling. American Flexible Coupling Co.

INSTRUMENTS AND CONTROLS

109 Measuring Instruments — Twelve-pp Bulletin 806 describes small-size receivers and draft, pressure and temperature gages said to give excellent readability and accuracy with a scale measuring only five in. high. Points out advantages and describes installation procedure; also shows clearance and cut-out dimensions. Covers diaphragm, bellows, and helix type gages and includes specifications on each. Republic Flow Meters Co.

110 Temperature Control — Catalog G-20 covers company's complete line of differential expansion temperature controls. Included are pictures of current types, a description of their operation, general specifications, and an instrument selection chart. Instruments are suitable for controlling temperatures or for high temperature safety alarms and cut-outs. Burling Instrument Co.

New and revised publications reviewed on these pages offer help on operating and maintenance problems. To order, use the Reader Service Cards, page 121.

111 Service Regulators — Revised Bulletin 1026, 20-pp, features company's line of service regulators. Rate-of-flow graphs illustrate mathematically the determination of maximum outlet pressure build-up and amount of gas relieved to atmosphere by extra safety device in case of complete failure of regulator. Rockwell Mfg. Co.

112 Purge Meter — Eight-pp Bulletin 120 describes company's line of Brooks-Mite and Sho-Rate purge meters for convenient, dependable small flow indication. Application data, design and construction details and capacity charts are included. Brooks Rotameter Co.

113 Feeder Control — "Application of Principles of Instrumentation to Liquid and Dry Feeders" is the title of 8-pp Preprint B-I-F-M65, which contains 11 flowparts diagrams. The purpose of the paper is to provide a basic knowledge of the application of instrument principles to gravimetric feeders, especially function of the controller in its various forms. Omega Machine Co.

114 Oxygen Analyzer — Bulletin 108A describes company's F3 Analyzer, showing how it makes its measurement directly upon oxygen content of gas — not upon some remote secondary relationship. Operating principle is illustrated, typical applications are highlighted, and technical data (operating ranges, response rates, sampling equipment) are also given. Arnold O. Beckman, Inc.

115 Test Equipment — Catalog R36A illustrates and describes complete line of test equipment, including instruments for servicing communications equipment, as well as all industrial electronic and electrical equipment. Also describes simplified methods of visual alignment. Weston Electrical Instrument Corp.

116 pH Equipment — Bulletin Q1305, 16-pp, includes a price list and specification data on pH recorders and controllers for use with company's electrodes and amplifiers. Specifications are written to enable user to select pH indicating, recording, or automatically controlling equipment best suited to his particular needs. Featured is a portable pH recorder designed for stream pollution studies, or for laboratory use where a permanent installation is not justified. The Bristol Co.

117 Oil-Leak Detector — Eight-pp Bulletin 80 provides a detailed explanation of the operation of the Paraprobe oil-leak detection system for steam-type fuel-oil heaters. Includes standard specifications, installation diagrams, and method of determining rate of flow of condensate. Davis Engineering Corp.

118 Standard Conversion Tables — Bulletin F-7255, 16-pp, gives thermocouple temperature-millivolt equivalents. Temperatures are expressed on the International Temperature Scale of 1948. The electromotive force is expressed in absolute units. Power engineers will find this a convenient pocket-size reference. Wheelco Instruments Div., Barber-Colman Co.

LIGHTING, COMMUNICATION

120 Lighting Equipment — Form 5736, 8-pp, describes company's line of battery-powered emergency lighting equipment. Diagrams, charts and specifications give essential data on models designed for permanent connection (emergency lighting-unit equipment), auxiliary lighting equipment (plug-in type), and a transparent plastic-cased battery. The Electric Storage Battery Co.

121 Signal Equipment — Tips on how to select suitable signals for any specific operation are offered in Bulletin 100, one of a series of bulletins — Nos. 100–125 — bound in this 40-pp catalog. Other bulletins describe electric horns, bells, lights, other signal equipment, with specifications, photos, wiring diagrams, dimensions, audibility rating charts, electrical characteristics and other technical data. Federal Sign & Signal Corp.

PIPING, VALVES, FITTINGS

122 Plastic Pipe — This illustrated booklet describes the special advantages

of Tenite butyrate plastic pipe as conduit for electrical power lines and telephone cable, together with typical applications. Booklet pictures pipe installations showing how it is laid, ease of joining, flexibility, resistance to corrosion, and adaptability. Eastman Chemical Products, Inc.

123 Graphitization in Piping — "Considerations in the Evaluation of Graphitization in Piping Systems" (Reprint TR-504) is a 10-pp illustrated article. Subjects discussed include sampling procedure; bend testing, impact toughness evaluation, and metallographic evaluation; uniformity of graphitization; and heat treatment. Grinnell Co., Inc.

124 General Purpose Valves — Supplement No. 1 to Catalog F-9, 32-pp, offers complete information on company's series of general purpose drop forged steel valves, gate, globe and angle types, sizes ¼ through 2 in. Includes descriptions of each type along with drawings showing component parts. Dimensions and other specifications are tabulated, and a pressure-temperature ratings table is included. Henry Vogt Machine Co.

125 Float Traps — Semi-steel float traps equipped with Duo-Step leverage for maximum power and valve travel, providing larger orifices for increased capacity and ability to handle unusual dirt conditions are described in this illustrated bulletin. Applications in maintaining constant levels, continuous drainage installations or for dual gravity service are discussed, and specifications outlined. Clark Mfg. Co.

126 Valve Couplings — Bulletin 551 presents engineering data on company's line of valve couplings, hose couplings and hose clamps. Includes dimensions for valve couplings, price list, and a table showing dimensions of standard hose couplings. C. B. Hunt & Son, Inc.

127 Quick-Seal Couplings — Quick connect-disconnect hose couplings are featured in this 20-pp bulletin, Form 7-55-20. Includes large cut-away views of coupling showing design and construction features. Single-check valve and double-check valve modifications (which seal off one or both ends of a fluid line the instant coupling is disconnected) are also covered. Tables and diagrams listing sizes and types of hose connection, and selection data included. Titeflex, Inc.

128 Hose Couplings — Data Sheet 3100 gives specifications and recommended uses on hose couplings and fittings. Types shown include short and long shank common couplings, barbed insert, quick-acting, reattachable, interlocking high pressure couplings. Also describes other methods of joining hose — clamps, nipples, Flexseal hose joint and flanges. The B. F. Goodrich Co.

PUMPS, COMPRESSORS

130 Plastic Pumps — Catalog 55 describes company's line of plastic pumps, including illustrations and diagrams of both standard and XB models. Complete operating and performance data along with materials of construction and recommended application tables make this a useful condensed catalog. Full details are given on design, and specifications and photos are included. Vanton Pump and Equipment Corp.

131 Horizontal Compressors — Bulletin L-640-B1C, 24 pp, presents single-stage horizontal compressors from 50 to 2000 cfm and from 10 to 150 psi. Gives information on basic specifications, standard equipment, capacity control, cylinder construction, other factors. A diagram of a complete installation is included along with cutaway views of major components and accessories. Installation photos and data chart provided. Worthington Corp.

MATERIALS HANDLING

132 Tractor Shovel — The engineering, design and production stories of company's HD-11G tractor shovel are pictorially presented in 8-pp Catalog MS-460. Includes specifications and describes various features which mean easier servicing for less time-down in the field, greater operator comfort. Allis-Chalmers Mfg. Co.

133 Crawler Tractor — The technical and operating story of manufacturer's 45 drawbar hp HD-6 diesel-powered crawler tractor is told in Catalog MS-461. Engineering, design and performance features are explained with the help of photos, and illustrations are also used in reviewing the engine which powers the tractor. In addition to specifications, the catalog lists matched equipment and accessories. Allis-Chalmers Mfg. Co.

134 Automatic Elevators — Automation in elevators is described in this 20-pp booklet, illustrated with photos of latest devices in modern buildings and valuable graphs and charts. A history of early elevators precedes details of the many improvements in today's elevators leading to the development of the automatic elevator. Charles W. Lerch & Associates.

135 Bucket Elevator Chains — Chains and drive wheels for bucket elevators and conveyors are described in 8-pp Catalog DC-855. Includes a detailed discussion and illustrations of this design chain. Types of available chains are listed along with various metals from which these chains are made. Tables list relative corrosion resistance and physical properties of chain metals. Beaumont Birch Co.

136 Roller Chains — Hints on conveying with roller chains and attachments are provided in Bulletin 55-11. Shows stock, made-to-order, and special attachments which can be furnished with Rex Roller Chain. Chain Belt Co.

137 Conveyor Belt Carriers — Sixteen-pp Bulletin 355 covers company's line of standard units, including their newest addition — a long center roll carrier with either 35 to 45 deg slope end rolls for greater carrying capacity on light materials, such as grain and wood chips. Describes a number of special carrier units, as well as trippers and accessories. Stephens-Adamson Mfg. Co.

VENTILATION, DUST CONTROL

139 Plant Ventilation — This bulletin describes industrial plant ventilators, giving dimensions, capacities, sectional drawings and operating conditions for power roof, continuous ridge, and round gravity ventilators that meet all exhaust and ventilating conditions. American Steel Band Co.

140 Dust Control Tips — Bulletin 636-3 offers practical engineering information on Dustkop industrial dust control, its installation, operation and maintenance. It tells how to figure your own system, how to build your own hoods and how to select the right dust collector for the job, and includes drawings you can use. Also pictures a wide range of models for various application requirements. Aget Mfg. Co.

141 Dust Filter Facts — Bulletin 559, 28 pp, explains in detail the distinguishing features of reverse jet filters. Aids in solving plant dust control problems are provided. Bulletin also contains schematic operating diagrams, performance curves for various types of dust, comparison chart of reverse jet vs conventional type filter performance and air engineering data. Special pages are devoted to planning and arrangement of filters to meet specific requirements. The Day Co.

. . . Outstanding Among This Month's Catalogs

142 Aluminum Pipe and Fittings — Aluminum pipe — for conveying everything from air to acid — is described in this 18-pp, Form AD197. Booklet presents characteristics and advantages for each major field of application. Specifications are provided, along with a description of appropriate fittings and methods of installation. Describes process industry applications and advantages. Similar treatment is accorded other fields, including pipelines, portable piping, and structural piping. Aluminum Co. of America.

143 Venting Fundamentals — Principles of venting flammable liquid storage and process tanks for effective operation, fire protection and low-cost maintenance are described in this 12-pp illustrated booklet. Explains principles as applied to non-conservation venting and conservation venting, storage tank filling, storage tank rodding and sampling, fuel tank filling, steam tracing. The Protectoseal Co.

144 Flexibility of Electronics — How flexibility of electronic temperature controls makes them useful in a wide range of commercial and industrial heating and air conditioning installations is explained in this 16-pp booklet, Bulletin SA-2681. Purpose of publication is to fill the gap between the theory of electronic bridge circuits and specific control layouts and circuit diagrams. Four basic features that give electronic control its flexibility and application to a wide variety of installations are described. Minneapolis-Honeywell Regulator Co.

CORROSION PREVENTION

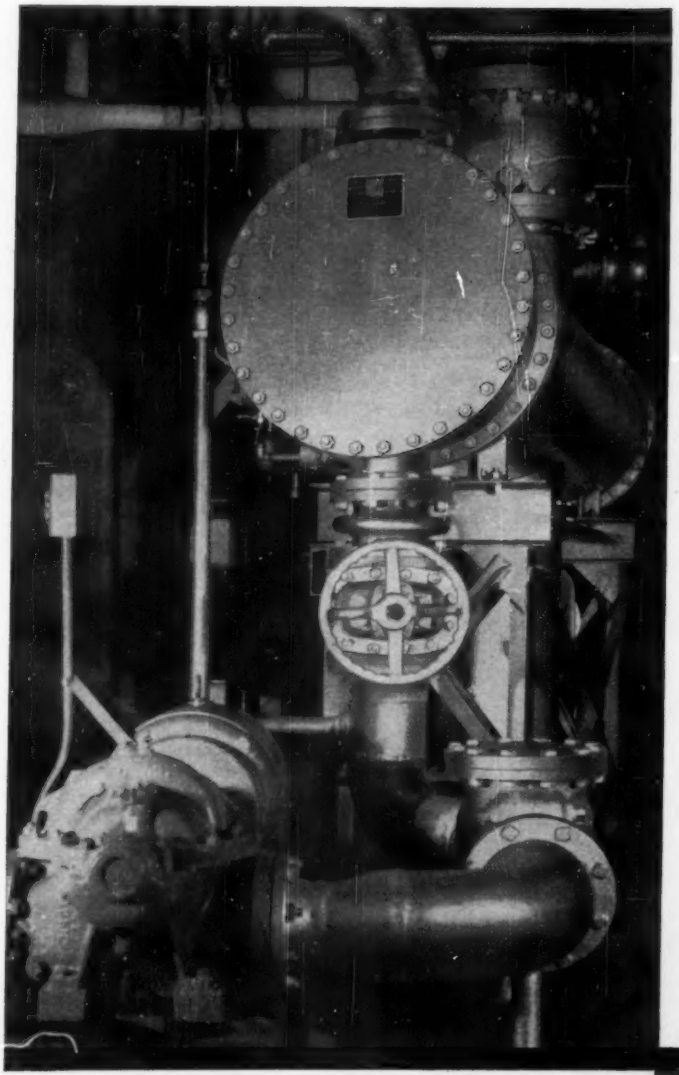
145 Zinc and Corrosion — "How Zinc Controls Corrosion," 32 pp, describes the many ways zinc lengthens life of steel products, and reduces maintenance costs. Drawings, charts, and photos together with brief comments present corrosion control characteristics of zinc coatings, zinc pigments, and zinc galvanic anodes. American Zinc Institute, Inc.

146 To Control Corrosion — "Corrosion the Thief of Industry" stresses three steps required for adequate corrosion control — analysis, specification and application. Photos show equipment protected

ON DUTY...

in Connecticut State Hospital's power plant

ROSS SURFACE CONDENSER



With a staff of 982 employees and care facilities for 3,016 patients, the Connecticut State Hospital, Middletown, Conn., is one of numerous institutions, public utilities, office buildings, refineries and other industries served by Ross Surface Condensers. Here, the Ross unit condenses the exhaust from a 500 kw turbine generator set, producing 26 in. Hg. vacuum.

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against corrosion by means of plastic coatings, metallizing, linings etc. Metal-Cladding, Inc.

147 Cathodic Protection — This 12-pp illustrated technical brochure presents a cathodic protection system for corrosion control. Describes effect of galvanic action on metals in contact with earth or water, and explains principles utilized by these systems to halt existent corrosive action or keep new installations free of it. Savings gained by such protection are discussed and case histories given. Some typical applications of the system as applied to underground pipe lines are shown, and company's engineering services are outlined. Harco Corp.

WATER TREATING

149 pH and Chlorine Control — The 12th edition of company's handbook "Modern pH and Chlorine Control," 100-pp, incorporating theory and practice of colorimetric analysis, serves as a reference for quantitative determination of pH, chlorine, phosphate, nitrite, sulfate, hardness and other special tests. Slide comparators and complete test kits are illustrated and detailed methods discussed. In addition to standard pH determinations, methods are outlined for quantitative analyses of phosphate, calcium, magnesium, silica nitrate hardness in feedwater. Concentration of anti-sliming copper or chlorine in cooling water can also be controlled by colorimetric methods described. W. A. Taylor Co.

150 Control Panels — Automatic controls for filters, water softeners, and various ion exchangers are described in 8-pp Bulletin 4178. Advantages of the steel cubicle method of installing instruments and electrical controls for a water conditioning plant are pointed out. Shows typical assemblies of conventional and graphic type cubicles, installations in various industries. The Permutit Co.

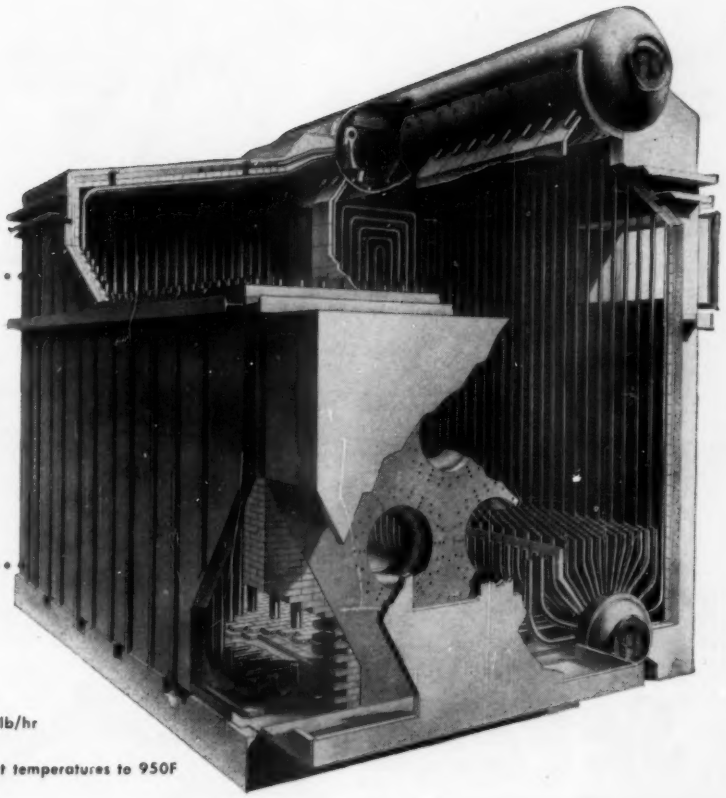
Bulletins reviewed here are offered primarily for qualified power engineers. Manufacturers may withhold literature from persons who do not state their job title and company. Some manufacturers also prefer not to send literature to those in foreign countries in which they have no sales representatives.

151 Improved Chlorinator — Catalog 70-10, 16-pp, describes company's Figure 1050A chlorinator for purifying water supplies, treating sewage and industrial wastes and for control of slime. A multi-colored flow diagram shows how chlorine gas and water are kept separate until they reach ejector system. Explains how this feature, and use of corrosion-resistant materials, prevents corrosion of equipment. Other chlorination instruments also described. Fischer & Porter Co.

TUBING SUPPORT SYSTEMS

152 For Instrument Tubing — Twelve-pp Catalog 255 describes and illustrates company's complete system for supporting instrument tubing of all types. Also included is the "Pin-Type" coupler,

Series "SC" STANDARD Steam Generator



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Burners, controls, upper drum mountings and other equipment requiring attention are located at the front of the unit. Heat recovery equipment and fans can be placed near the operating aisle for either single or multi-unit installations, providing unusual accessibility and ease of operation.

Write us today for further information on how the Series "SC" Standard Steam Generator can meet your individual plant needs for power or process work. *Foster Wheeler Corporation, 165 Broadway, New York 6, New York.*

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Here is the tough, dependable packing you've been looking for. Style 177AI is built to take punishment . . . to easily withstand pressures as high as 2000 psi . . . remain resilient at temperatures to 1200°F. It's a packing that will give you the kind of service you've always wanted in high temperature valves, soot blowers, gauge glass fittings and similar applications.

Style 177AI is dry graphite lubricated to reduce friction to a minimum. Each strand of the closely braided asbestos yarn top jacket is reinforced with Inconel wire. Core consists of long fibre asbestos and flake graphite.

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with which all major units of the system are now equipped. Specification data is included. Instrof, Inc.

153 Tubing Supports — Features and advantages of company's line of tubing supports are discussed in 16-pp Bulletin 955-D. Installation diagrams illustrate straight sections, connectors, extension connector, drive rails, connector fittings, offset reducer connector, fittings, covers, raceway, fastening devices, hangers. Specifications included. P-W Industries, Inc.

OTHER EQUIPMENT

154 Sprayed Coil Dehumidifiers — Bulletin 7827, 20-pp, describes company's central station type sprayed coil dehumidifiers, featuring a special 10-pp section of application data. Water dilution, high humidification, evaporative cooling and selection for size are among the subjects discussed. Also included are symbols, formulas, and tables and curves required for accurate selection. Design and construction features are outlined, and installation drawings included. American Blower Corp.

155 Piston Packing — Sixteen-pp Bulletin 5503 presents engineering data on Darcova Pumcups for packing pistons of air cylinders, hydraulic cylinders and reciprocating pumps. Included are operating diagrams and a list of typical installations, as well as helpful data on Pumcup compositions, textures and types made available for specified pressure, temperature and corrosive conditions. Proper compositions are identified for many fluids, including various gases, acids, and alkalis. Darling Valve & Mfg. Co.

156 Closed Circuit System — The operation of Turbo-Dryers for continuous drying, cooling or subliming materials which are fragile, obnoxious, heat sensitive, oxidizable, or wet with solvents that are hazardous or must be recovered is presented in Bulletin 5507. Cutaway views and installation photos are included. Wyssmont Co., Inc.

157 Solvent Recovery — Form 4410D, 36-pp, on company's carbon system of solvent recovery gives technical data on activated carbon and describes efficiency and economy of recovering solvent vapors in a variety of industries. Describes equipment and applications and includes photos and graphs showing resistance to air flow. Also lists lower explosive limits of various solvents and a selection of available literature. Carbide and Carbon Chemicals Co., Div. Union Carbide and Carbon Corp.

158 Corrosion Resistant Equipment — Catalog C-12, 32 pp, describes a line of corrosion resistant industrial equipment and features new materials of construction. Evaluates equipment molded from polyvinyl chloride, epoxy glass and polyester glass, giving data on resistance to chemicals and heat. Includes information on cements, and on mortars for brick and tile. Rating data for exhaust fans, a new method of fitting pipe on the job, and a revised chemical resistance table included. Haveg Corp.

159 Products and Services — Automatic control and instrumentation components; water conditioning and steam testing equipment, chemical feeding devices; chemicals for food processing, paper processing and for metal protection — these are some of the subjects discussed in 28-pp Bulletin GSP901. Summarizes company's

This

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ENGINEERS and consultants helped prepare this new Bulletin No. 953 . . . "Controlled Volume Pumps for Water Treating Systems."

It has been termed, "a most important contribution to water treating literature."

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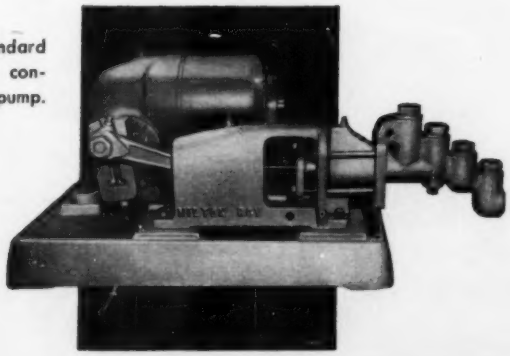

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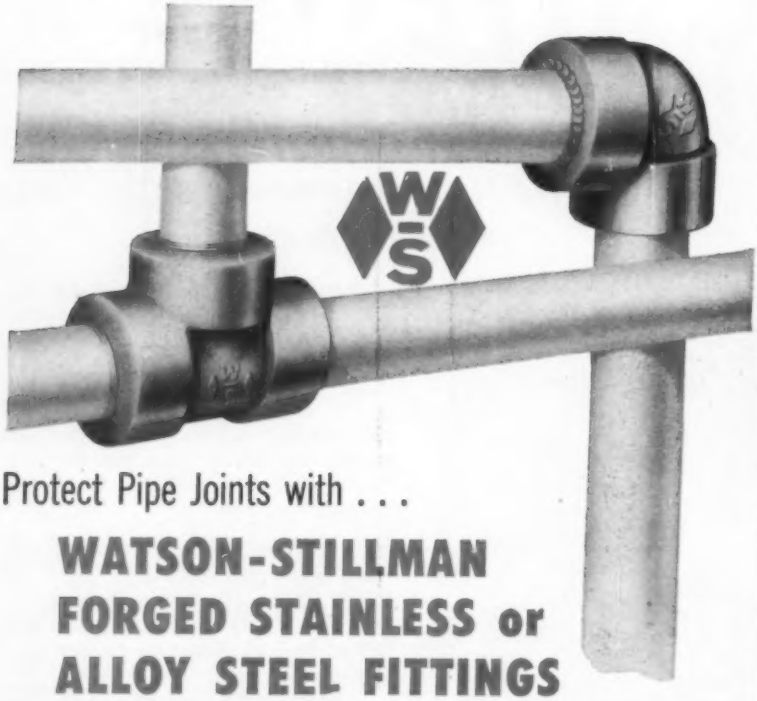

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IN CORROSIVE SERVICE your pipe joints take a beating—fluid velocity and turbulence accelerate corrosion wherever there is a change in direction of flow.

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products and services as well as the products and services of its three subsidiaries — Calgon, Inc., Hall Laboratories, Inc., and the Buromin Co. Hagan Corp.

160 Steam Generators — Bulletin 55-1, 22-pp, describes company's products and services, including not only steam generators but also custom metal fabrication. There are many photos of boilers in various stages of assembly. Engineering drawings of boilers producing up to 500,000 lb of steam per hr on standard fuels are included, as well as illustrations of units for waste heat application and those designed to utilize refuse for fuels — wood chips, coffee grounds. The Wickes Boiler Co.

161 On Fuel Economy — Purpose of this folder is to alert industrial fuel users to losses they may be incurring in their plants — and to show how such losses can be detected and corrected. Discusses major sources of hidden waste and loss — specification and purchase of less than optimum fuel; inadequacy of steam plant records or incorrect interpretation; and complexity of fuel values, availability, and pricing. Fuel Engineering Co. of New York.

162 Heat Transfer Equipment — Dimensions, data and capacities for easy selection of more commonly used types of heat transfer equipment are provided in 12-pp Bulletin 31. Covers converters, water heaters, condensate coolers. Buxton Mfg. Co.

163 On Hardness Testing — Here's a chart showing the approximate relation between hardness by various testing systems and tensile strength of carbon and alloy steels. Hardness systems covered are Brinell, Monotron, Vickers and Rockwell (B, C, and E scales). Tubular Products Div., The Babcock & Wilcox Co.

164 Seamless, Welded Tubing — This 8-pp catalog describes major classifications of carbon and alloy steel tubing; mechanical, pressure, airframe and aircraft mechanical. Covers both seamless and electric resistance welded tubing, as well as information on tube fabricating and forging. Ohio Seamless Tube Div., Copperweld Steel Co.

165 Silent Heater — Bulletin H-10 5 stresses noiseless and vibration-free operation of company's HusHeater. Describes applications in various industries, operation details, and includes installation and ordering information. Sims Pump Valve Co., Inc.

166 Metal Stair Treads — Extruded and cast metal safety treads recommended for stairway repair are described in this illustrated folder. Tells how to repair stair treads that have become worn and dangerous. Wooster Products, Inc.

167 Heat Exchange Equipment — Physical and dimensional data charts for quick selection of heat exchange equipment are contained in Bulletin C-3008. Points out advantage of serrated, helically-wrapped fins. Drayer-Hanson, Inc.

168 Clarifiers and Thickeners — Bulletin W-800B-S-6000B, 16-pp, answers questions on design requirements of clarifiers and thickeners for a wide range of capacities and solids removal loads. Illustrated with photos, dimensional drawings and tables, bulletin explains why circular sedimentation basins, sludge scrapers and central inlet wells are features of company's clarifiers and thickeners. Infilco Inc.

Scandinavia increases steam capacity, cuts costs burning coal the modern way

With its old power equipment overloaded by an ever-increasing demand for steam, Scandinavia Belting Co., Charlotte, N.C., took stock of its power situation. Boiler room efficiency was low and maintenance excessive; pressure fluctuated and labor costs had become a problem. Deciding to modernize, Scandinavia instituted a survey of all available fuels. On the basis of cost, coal was chosen. Today, after modernization, Scandinavia's power plant has increased steam capacity 150%, reduced fuel costs 15% and cut labor costs 70%. Increased efficiency and automatic operation have reduced the work force and assured a dependable steam supply at steady pressure with ample reserve for load growth. In addition, the cleanliness of the new plant has been an important factor in raising the morale of the employees.

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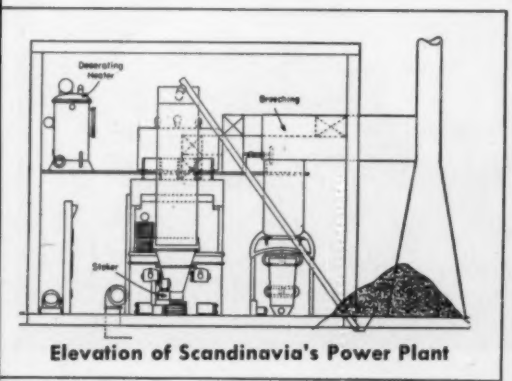
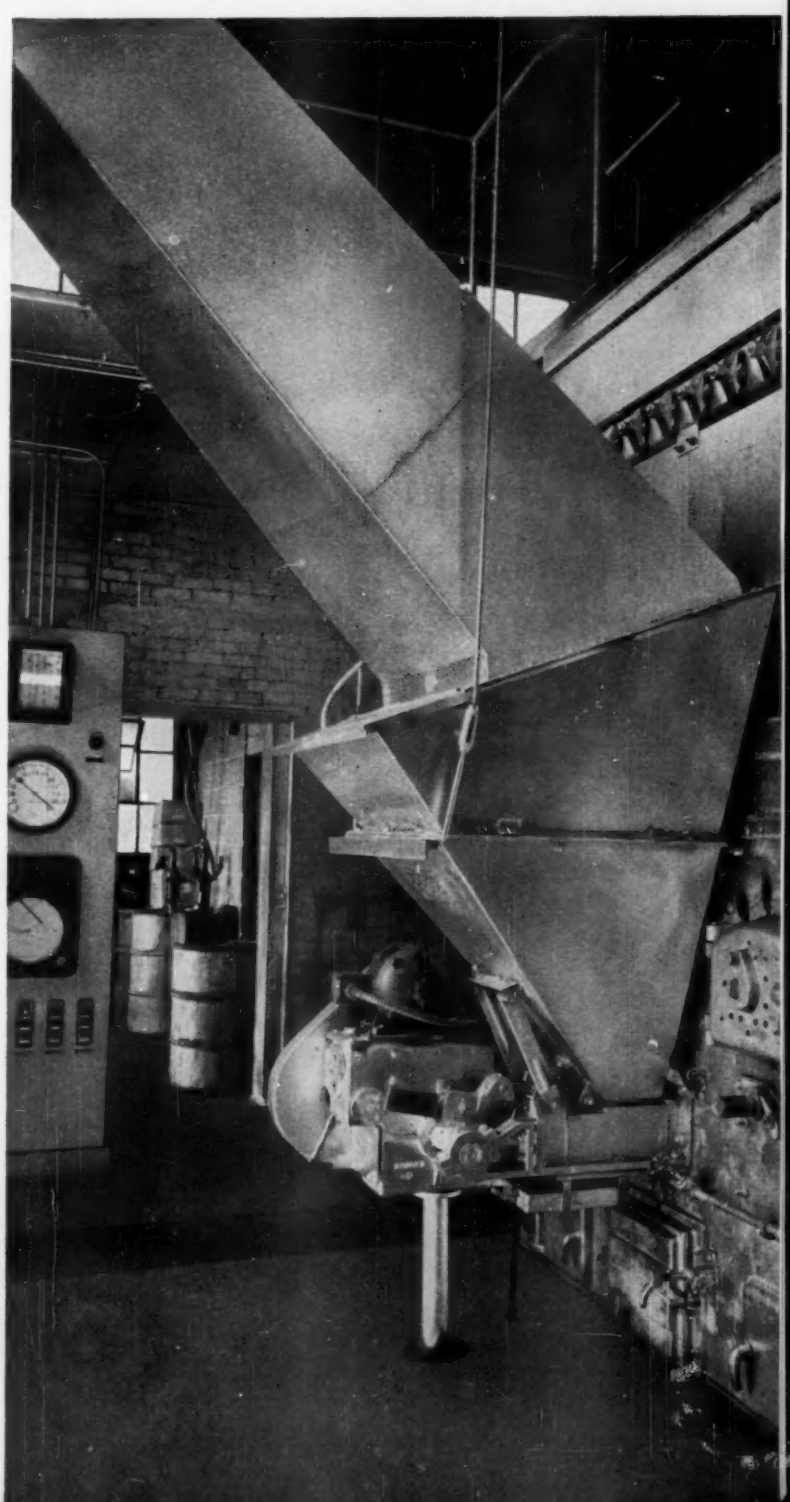


Elevation of Scandinavia's Power Plant



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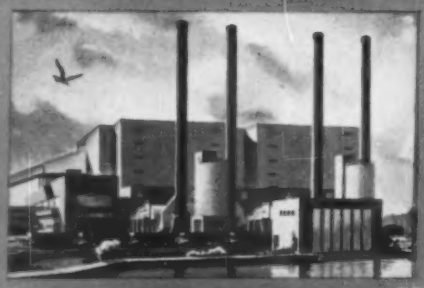
1 **KANAWHA RIVER** 9113

Appalachian Electric Power Co.
on the American Gas and Electric System

Two B&W Pressure-Fired Radiant Reheat Boilers with Gas Recirculation and Divided Furnace Construction.



2 **ST. CLAIR** 9240

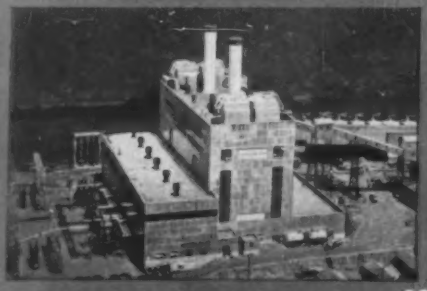
Detroit Edison Co.

Four B&W Radiant Reheat Boilers with Gas Recirculation and Divided Furnace Construction.

3 **TANNERS CREEK** 9251

Indiana and Michigan Electric Co.
on the American Gas and Electric System

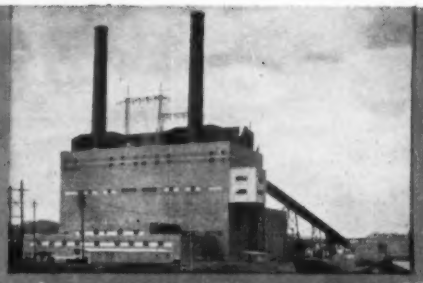
Three B&W Pressure-Fired Radiant Reheat Boilers with Gas Recirculation and Divided Furnace Construction.



4 **SHAWVILLE** 9310

Pennsylvania Electric Co.

Two B&W Radiant Reheat Boilers with Gas Recirculation and Divided Furnace Construction.



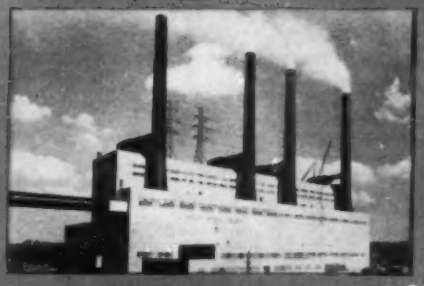
5 **MUSKINGUM RIVER** 9374

Ohio Power Co.
on the American Gas and Electric System

Two B&W Pressure-Fired Open-Pass Reheat Boilers with Gas Recirculation.

6 **EASTLAKE** 9386

The Cleveland Electric Illuminating Co.



7 **PHILIP SPORN** 9417

Appalachian Electric Power Co. and Ohio Power Co.
on the American Gas and Electric System

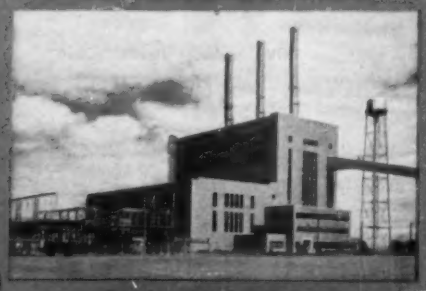
Four B&W Pressure-Fired Radiant Reheat Boilers with Gas Recirculation and Divided Furnace Construction.

8 **KEARNY B** 9556

Public Service Electric & Gas Co.

9 **BARRY** 9557

Alabama Power Co.



10 **JUSTIN R. WHITING** 9574

Consumers Power Co.

Three B&W Radiant Reheat Boilers.

10 BEST ANNUAL HEAT RATES

reflect INCREASING EFFICIENCY in power generation

Annual plant net heat rates of the ten most efficient central stations in the United States in 1954 — as reported by the Federal Power Commission — are led by Kanawha's record 9113 Btu per net kwhr. They are strong vindication of the foresighted utilization of major engineering advances which are taking this nation so far and so fast along the road of power generation progress. And the development of these advances has been possible only through the efforts of the electric companies and their primary suppliers working cooperatively to provide more electricity more efficiently.

In most of these leading stations, B&W Boilers designed with the most advanced features are contributing substantially toward achieving the remarkable plant efficiency levels reported. For example, at Kanawha the B&W vertically-fired Radiant Boiler units utilize:

PRESSURE-FIRING
To eliminate air infiltration, reduce stack loss and assure greater efficiency.

CYCLONE STEAM SEPARATORS
To assure positive natural circulation at high pressures with lowest auxiliary power cost, and send steam of highest purity to the turbines.

DIVIDED FURNACE CONSTRUCTION
To hold building volume to the minimum while achieving required furnace cooling surface.

Just behind the ten leaders are more plants — many with B&W Units — producing abundant, economical power in all parts of the country.

Welcoming its responsibilities as a major supplier, B&W continues to apply the knowledge derived from almost a century of boiler engineering, design and fabrication experience. And to help foresee the needs of the future, the practical results of an extensive B&W program of research and development are continuously being enlisted in the efforts to achieve still higher levels of steam-electric generating efficiency.

G-738

BABCOCK & WILCOX

BOILER DIVISION

For more data circle 525 on Post Card

CONSTRUCTION NEWS

Bridgeport, Conn. — United Illuminating Co. (Bridgeport Div.) has approved plans for the construction of a new 300,000-kw generating station, to be known as the Bridgeport Harbor station, on the west side of the Pequonnock River. Initial generating unit of 80,000-kw is scheduled to be completed and in service by the fall of 1957. Cost of project when completed to be in excess of $13,000,000.

Savannah, Ga. — The Savannah Power & Light Co., 27 W. Bay St., has recently announced the purchase of a 25 acre tract of land on the eastern side of the city to be used as site for future service facilities to augment present quarters on Indian St., which are fast becoming inadequate. Details of plans and specifications as yet unannounced but it is expected that work will be begun on the project early in 1956.

Boise, Idaho — The Idaho Power Co., 1220 Idaho St., has plans under way for two new hydro-electric generating plants at company's Brownlee and Oxbow sites on the Snake River. Contracts for eight generating units have been let — four for each project. Initial capacity will exceed 800,000-kw in power capacity. In the future, additional generators planned could bring ultimate capacity to 1,750,000-kw. The first 90,000-kw generating unit will be in operation early in 1957, — the remaining three within twenty months thereafter. Cost of equipment estimated at $14,000,000.

Chicago, Ill. — Commonwealth Edison Co., 72 W. Adams St., has authorized and approved plant expansion program, cost to exceed $600,000,000, over five year period through 1959. Company will spend $277,000,000 for expanding and improving its generating facilities; $309,000,000 for transmission lines and other distribution facilities; and an additional amount of $14,-000,000 for improvement of company's general plant and facilities. Construction costs for 1955 and 1956 will be about $240,-000,000 — with the following three years to run $135,000,000, $125,000,000, and $100,000,000, respectively.

Indianapolis, Ind. — Indianapolis Power & Light Co. has disposed of a stock issue totaling $8,000,000, proceeds to be used primarily for 1955–1956 expansion and improvement program, including generating facilities, power substations, transmission lines and other operating facilities.

Kansas City, Kansas — Board of Public Utilities has authorized plans for expansion and improvement in municipal electric generating station. Work will include installation of 44,000-kw generating unit and auxiliary equipment. Burns & McDonnell Engineering Co., 95th & Troost Streets, Kansas City, Mo., is consulting engineer.

Sterlington, La. — Louisiana Power and Light Co., 142 Delaronde St., New Orleans, La., has plans under way for the construction of new steam electric generating unit at company plant at Sterlington. It will be equipped with initial capacity of 200,000-kw and is scheduled to be in operation the latter part of 1956

St. Paul, Minn. — Northern States Power Co., 15 S. Fifth St., Minneapolis, Minn., has arranged an expansion and improvement program at company's High Bridge Plant to cost about $15,000,000, including generating facilities, transmission lines and power substations. Program includes installation of additional steam generating unit of 100,000-kw capacity. McGough Bros., 1954 University Ave., St. Paul, Minn., general contractors.

Chillicothe, Mo. — City Council is arranging fund of $1,395,000 through bond issue for expansion and improvement of municipal electric power plant. Work will include installation of new generating unit and auxiliary equipment.

Newark, N. J. — Public Service Electric & Gas Co., 80 Park Place, has arranged for bond issue of $35,000,000, proceeds to be used in connection with 1956 construction program, including extensions in generating facilities, transmission lines, power substations and other work.

New York, N. Y. — Consolidated Edison Co. of New York, Inc., 4 Irving Place, has arranged financing in the amount of $100,000,000 credit with 15 local banks, proceeds to be used for construction purposes, including extension in power lines, power plants, power substations and other operating facilities. Expenditures by the company on 1955–1959 construction program estimated at approximately $475,000,000.

Rochester, N. Y. — Rochester Gas & Electric Corp., 89 East Ave., subsidiary of General Public Utilities Corp., New York, N. Y., has arranged for financing in the amount of $100,-000,000, proceeds to be used in connection with major projects in the expansion program, including important additions to generating capacity, modernization of generating plants and substations, new transmission lines and reinforcements. Construction program calls for annual outlay of approximately $20 million annually for the next five years.

Canton, Ohio — American Gas & Electric Co., 30 Church St., New York, N. Y., has completed plans for proposed construction of new steam-electric generating unit at the Muskingum River plant of its Ohio Power Co., subsidiary. New turbine generator will have an initial capacity of 225,000-kw, with high-pressure boiler and accessory equipment. Entire program to cost about $28,000,000, including extensions in transmission lines, power substations and other operating facilities. Installation to be completed about June 1957.

Portland, Oregon — Pacific Power & Light Co., Public Service Building, has disposed of a bond issue, totalling $10,000,-000, proceeds to be used primarily on new construction, including generating facilities, power substations, transmission lines and miscellaneous work.

Portland, Pa. — Metropolitan Edison Co., eastern Pennsylvania subsidiary of General Public Utilities Corp., has authorized plans for the erection of a new steam-electric power plant on local site acquired for the purpose. The first unit will be equipped for a capacity of 165,000 kw, the largest in the upper Delaware Valley and will be in service by April 1958. A second unit will follow of greater capacity — with installation capacity to ultimately exceed 1,000,000 kw. Plant will be erected on a 132 acre site and is estimated to cost $25,000,000. Main office of company — Reading, Pa.

Anson, Texas — City of Anson, Texas, is arranging financing of $2,500,000 through bond issue for new municipal electric generating plant and distribution system.

El Paso, Texas — El Paso Electric Company, 213 N. Stanton St., subsidiary of Engineers Public Service Co., New York, N. Y., plans construction of new steam electric generating unit at its Rio Grande plant, at an estimated cost of $6,400,000. Stone and Webster Engineering Corp., New York, N. Y., is engineer and contractor.

Waco, Texas — Brazos Electric Power Co., Amicable Building, has approved plans and will proceed at once with work on expansion of transmission lines, substations, and important improvements to existing facilities in the Waco area. Cost of this work to exceed $2,300,000.

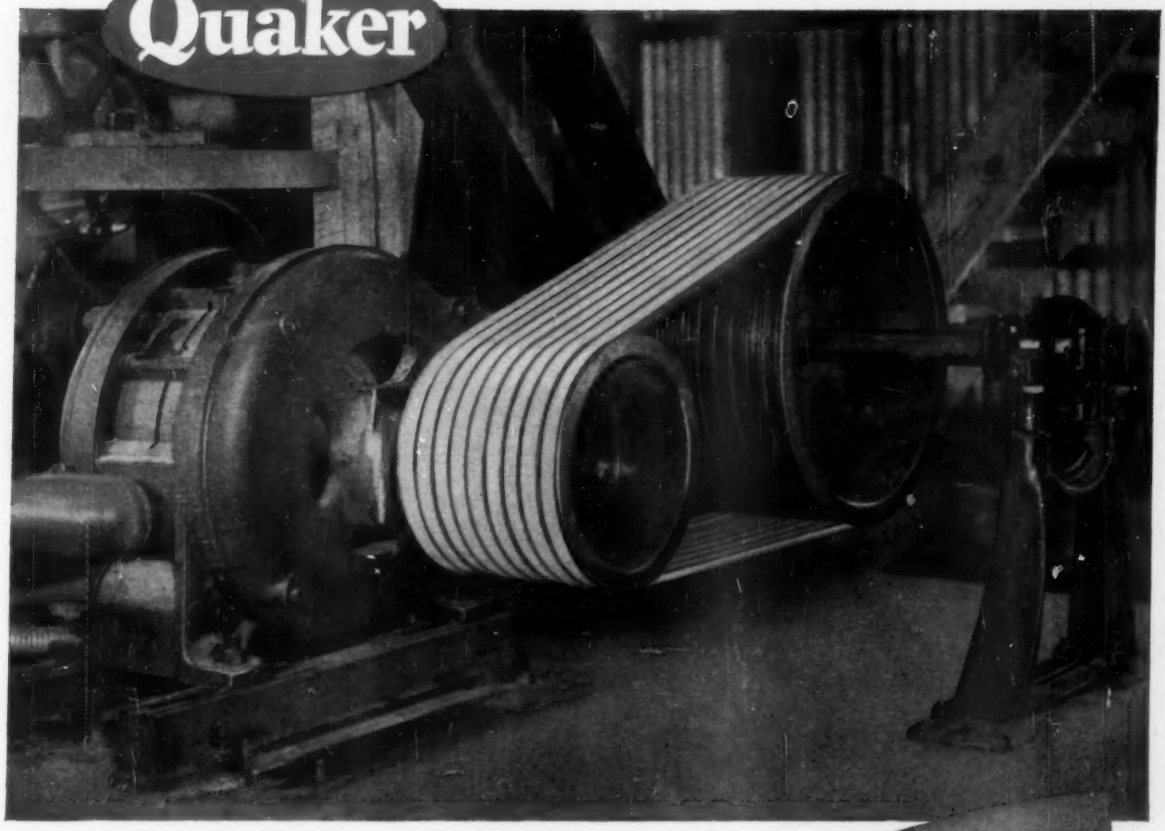
Rutland, Vermont — Central Vermont Public Service Corp., 121 West Street, has plans under consideration for the development of a hydro-electric power plant on the Lamoille River, East Georgia. Cost of this project, if developed, will exceed $2,000,000. Charles T. Main, Inc., 80 Federal St., Boston, Mass., is engineer.

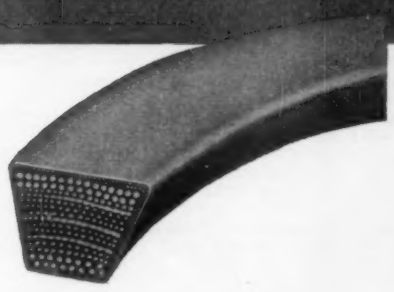
Seattle, Wash. — Puget Sound Power & Light Co., Stuart Building, has plans under way for the construction of an 85,000-kw hydroelectric generat ng plant on site selected for the purpose on Upper Baker River. Cost of installation when completed estimated in excess of $27,000,000. Company also proposes expansion of Lower Baker River plant with the installation of another 55,000-kw of added capacity. Both projects will cost an estimated $35,000,000, with completion planned for mid 1959.

Tacoma, Wash. — Board of Public Works, Tacoma, Washington, has authorized plans for the construction of a hydro-electric dam on the Cowlitz River. Details of the plant's size and capacity will be announced at a later date. Cost reported in excess of $10,000,000.

Alma, Wis. — Dairyland Power Cooperative, 2615 East Avenue, La Crosse, Wis., has plans under way for new addition to steam electric generating plant at Alma, previously noted in these columns, to include installation of new turbine generator, high pressure boiler, and auxiliary equipment. Cost of project estimated close to $8,500,000. Vern E. Alden Co., 33 N. La Salle St., Chicago, Ill., is engineer in charge.

Quaker





Low stretch, high flexing

stands up to shock impacts

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Strong and tough for large heavy duty multiple pulley drives, this V-belt gives long trouble-free performance where shock loads are encountered. Made of high tensile rayon cord, pre-stretched by exclusive heat stretching process. High traction jacket encloses multiple layers of rayon embedded in premium cushion rolls. All Quaker-Quaker Pioneer multiple V-belts are perfectly matched, assuring that each belt carries full share of load. Our complete line of industrial rubber products also includes hose, packing and moulded rubber for every use.

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H. K. PORTER COMPANY, INC.

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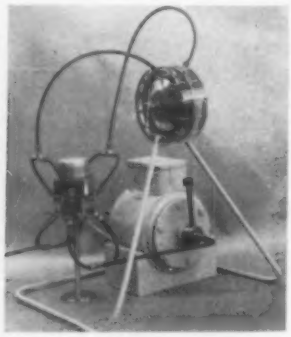
San Francisco 7, California

For more data circle 526 on Post Card

EQUIPMENT NEWS

1—CONTROLLED VOLUME PUMP for downhill pumping service

Minus Delta P Pumps are designed to accurately meter liquids or gases against negative discharge pressures. These controlled volume pumps are claimed ideal for all low capacity flow control problems that involve metering from high



suction to lower discharge pressure. According to manufacturer, the units are immune to pressure variations in the system, only requiring that suction pressures be maintained (naturally or mechanically) at least 5 psi above discharge pressures.

These low cost pumps come in four standard sizes of approximately 3, 15, 75 and 375 ml per cycle. Capacity is manually or automatically adjustable during operation through stroke length or speed control. Standard materials are 316 stainless steel with Neoprene or Tygon trim. Company reports that leakproof construction of the pumps lets them handle dangerous and corrosive materials. Milton Roy Co.

2—WIRE STRIPPER removes insulation chemically

Chemclean 493 is announced as an economical wire stripper, simple in operation, non-flamable, which chemically removes Formvar, Formex, Isonel and baked enamel coatings from wire, eliminating mechanical breakage and distortion. The material is formulated so that wire dipped into it is uniformly coated with the stripper. The bond between insulation and wire is broken and insulation is wiped off, leaving wire ready for soldering or other processing. Chemclean 493 will also remove various other organic finishes and may be used on vertical and overhead surfaces. Chemclean Products Corp.

3—MECHANICAL SEALS for use on process pumps

According to company, Unitary Seals have several distinct features: one-piece assembly (entire unit, including sleeve and gland, ready for quick installation); pre-set at factory; a collet-type drive; an external lock drive designed to be readily accessible; circulating connections in glands, provide cool, clean lubrication to add further life to seal; and long life, all sealing faces being precision lapped, plus all high pressure seals pressure balanced. Unitary Seals are designed for use on rotary shafts of boiler feed pumps, chemical pumps, oil refinery pumps, digestor circulating pumps and other process pumps. Bulletin AD-151 gives details. The Garlock Packing Co.

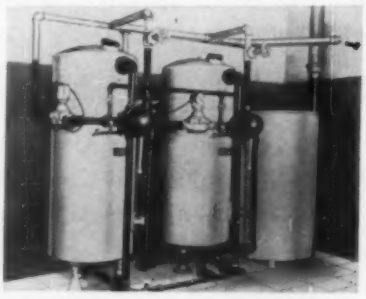
4—ROTARY ACTUATOR for remote control of valves

This control device has an internal helix arrangement which converts the in-line motion of a hydraulic or pneumatic cylinder into a rotary movement. It is reported especially applicable to remote control of valves, and can be operated with air, gas, or hydraulic pressure. Actuators may be furnished with "fail-safe" provisions.

The rotary actuator can be designed to produce any reasonable degree of rotary movement desired from 0 to 360 deg, or more if necessary, by increasing the overall length of the helix piston rod assembly. The actuator can be made to stop at any rotation point through the use of switching. By using a slip clutch in the unit, many varied rotary sequences can be obtained. It is thus possible to have unlimited rotation by a series of partial rotation cycles, company explains. A wide range of inch-pound torque requirements are met with five standard models from 3-in. bore, 350 in.-lb of torque at 100 psi, to 8-in. bore, 3360 in.-lb. Carter Controls, Inc.

5—WATER SOFTENERS come as package units

These water softeners are sold as package units, so that only simple connections are needed to fit a unit into a water system. A supply of company's Resin C-300, a high capacity resinous exchange material, is provided. Each unit consists of a brine tank and a softener tank, with their controls and piping in place. Twin units — two softener tanks with a single brine tank — also are available. With a twin, one tank is always on the line to supply soft water while the other is being regenerated. Flow rates can be as high as 175 gpm for a single unit, or 350 for a twin, with capacities between regenerations ranging up to 1,500,000 grains for a single unit. Hagan Corp.



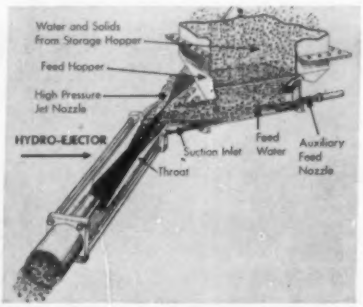
6—COAGULANT for turbid river and surface waters

Nalco 600 — a polyelectrolyte — is announced as a low-cost, low-dosage coagulant and coagulant-aid which shows most promise in coagulating turbid river and surface waters for industrial and cooling use. According to company, it will effect excellent coagulation in many cases where presently available treatments are ineffective and where iron and alumina floc carryover is a problem. Nalco 600 is also recommended for waste water treatment as well as for paper mill treatment of water for general service and for setting in savealls. A clear, liquid, alkaline and non-corrosive to steel, the product has also proved useful in lime-soda plants and processes. National Aluminate Corp.

Described on these pages are new and improved products. Use Reader Service Cards on pages 121–122 to ask for more information on them. Just circle the item numbers of all the products in which you are interested.

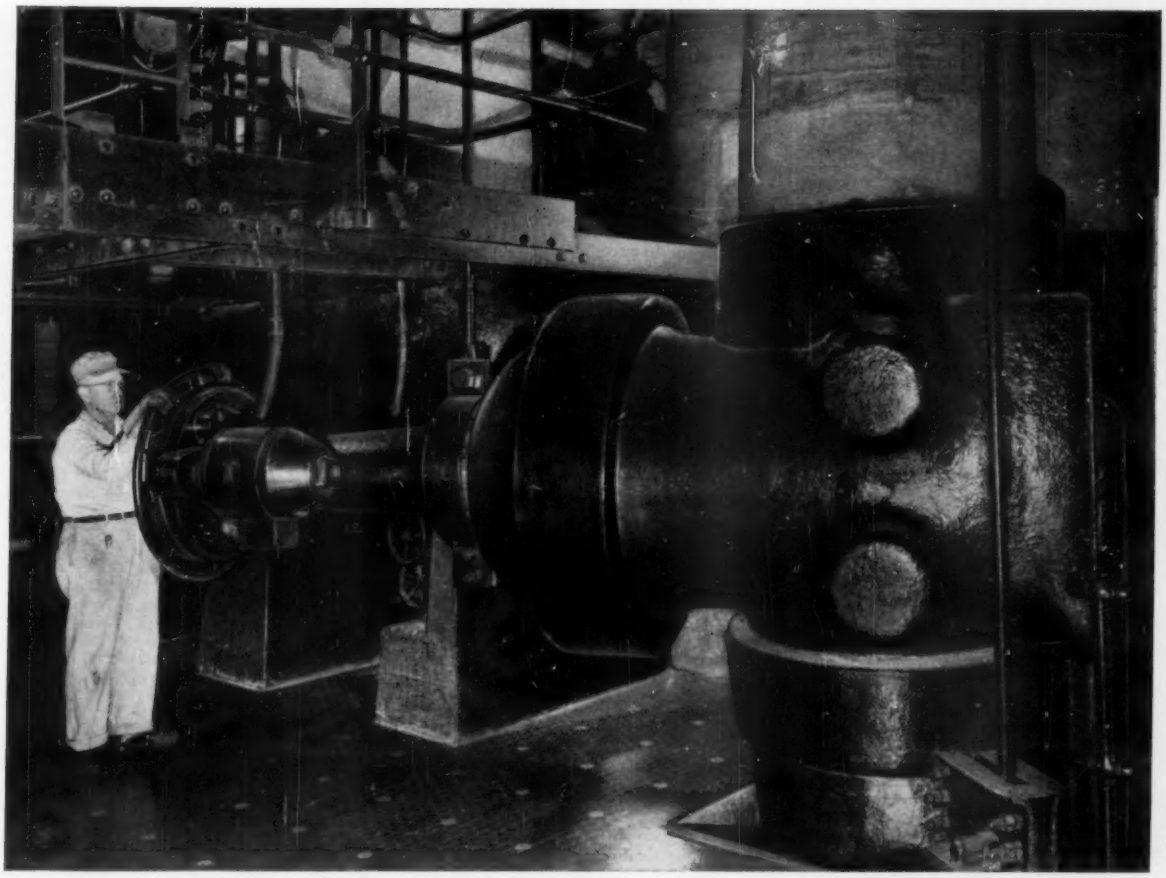
7—JET PUMPS for transporting solids through pipelines

Available in sizes for 4-, 6-, 8-, and 10-in. pipelines, the A-S-H Hydro-Ejector is announced as offering design simplicity, ease of installation, and low maintenance. Because jet nozzle tip is out



of the path of the materials being handled, it cannot interfere with the free flow of solids, it is noted. The unit is installed with a water-tight housing with access door, observation window and emergency flow connection which encloses the feed hopper and the discharge opening of the storage hopper. This is claimed to prevent flooding of the operating floor during overfeeding or when draining flooded type storage hoppers.

Iron pyrites can be transported in the same system which conveys bottom ash or furnace slag. This combined operation saves time and water, company points out, and uses the greater specific gravity of a water-and-ash mixture to carry the heavy pyrites at a higher rate. The Hydro-Ejector can be equipped with



Dividends from this Crane valve over 30 years... 6¾ billion kilowatt-hours

Over thirty years ago, this 30-inch Crane steel gate valve was put in service at Commonwealth Edison's Crawford Station in Chicago.

As of May, 1955, unit No. 1 on which this motor-operated valve is installed, had been in operation more than 150,000 hours. Total power output generated with this valve in service was approximately 6,750,000,000 kilowatt-hours.

The valve is on reheat steam service with working conditions of 100 psi. at 700 degrees F. Never out of the line, and given but routine maintenance attention since installed in 1925, the valve's performance remains completely satisfactory.

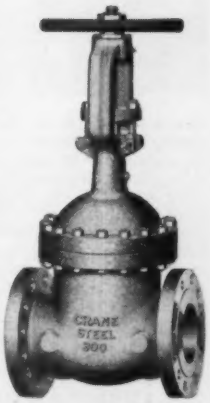
Seating action is positive and tight; bonnet-joint and stem seal are tight; operation is smooth.

There is nothing special about this rising stem, cast carbon steel valve—nothing but its dependable Crane quality. Development of steel valve castings was pioneered by Crane; long life and low maintenance are deeply rooted characteristics of Crane valves.

In steel valves, as in other materials, the Crane line is most complete: gates, globes, angles, checks and stop-checks—bolted, Pressure-Seal, and Lip-Seal bonnet designs—screwed, flanged, or welding ends—sizes up to 24 in.—pressure classes up to 2500 psi.

Your Crane Representative can give valuable help in specifying and ordering.

Crane Co., General Offices, Chicago 5, Ill. Branches and Wholesalers serving all industrial areas.



CRANE *Since 1855*

VALVES & FITTINGS • PIPE • KITCHENS • PLUMBING • HEATING

For more data circle 527 on Post Card

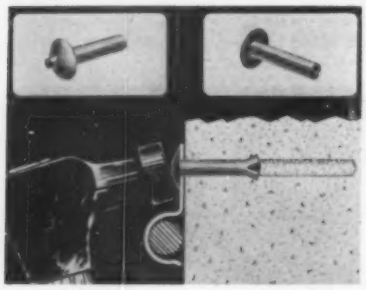
special gaskets to withstand effects of acids, alkalis and high temperatures. The Allen-Sherman-Hoff Co.

8—HEAVY DUTY FANS have aerodynamic design features

Streamline contours are given to all surfaces of Axial Airfoil Type L Fans that contact the air stream. The hub design is contoured and formed to approximate the motor diameters and varies from 25 to 70 per cent from the wheel diameters. This feature is reported to eliminate turbulence over motor and back flow. The aerodynamic blade design produces an even distribution of air velocity from hub to tip, without "dead spots," says manufacturer. Wheels of two, four, six and eight blades are available. Eight models available include fans with direct and V-belt drives. Fourteen wheels from 12- to 72-in. diam. are manufactured and, in all, more than 500 models are cataloged to meet many requirements. Wheels can be had in alloys capable of resisting corrosion and high temperatures. Fans can be supplied with six types of acid resistant coatings. Bulletin AA-101 gives full data on this line. Chicago Blower Corp.

9—DRIVE RIVET for fastening metal to masonry

Announced as a low-cost method for attaching metal to masonry, the one-piece Southco Masonry Drive Rivet can be used to nail to brick, cinder blocks, concrete, and similar materials. It can be used for sandwich construction of



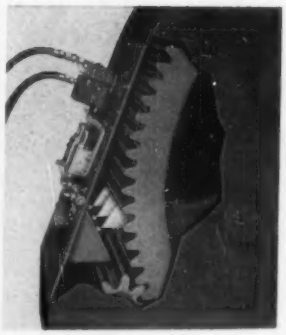
side walls, enamel facing plates, and corrugated asbestos or metal siding. Construction is fast and simple: you drill a hole, insert the rivet, and drive with an ordinary hammer. Made of 2117-T4 aluminum with stainless steel pins, rivets are available in six lengths, from 1½ in. to 1¾ in. by ¼ in. increments. One diameter — ¼ in. — handles every masonry fastening job. All heads are full brazier type except the 1¾ in. length which is 100-deg countersunk. Southco Div., South Chester Corp.

10—LUBRICATING KIT holds handy assortment of oil cups

For replacement and plant maintenance purposes the Lubrikit provides a boxed assortment of 95 oil cups of 29 different types. These are the oilers most used for these purposes, as shown by manufacturer's sales records. Each type of oiler comes in its own separate bin within the kit, and the contents of each bin are described on the inside of the cover. The kit is being introduced at less than $15.00. Gits Bros. Mfg. Co.

11—SPRAY PANEL for direct lubrication of gears

Spray Valve Panels are designed to spray-lubricate bull gears and girth gears such as on grinding mills and kilns, and other spur or herringbone gear trains. The self-contained panels are fastened to gear housings or framework and spray lubricant directly to pressure side of gear teeth. Measuring approximately 2- by 3- ft, these panels feature stainless steel spray valves having built-in nozzles. Central pumping units deliver gear lubricant at regular intervals through a circuit of Dualine measuring valves. The measuring valves distribute lubricant under pressure to spray valves where it is mixed with air to form a penetrating spray. Bulletin 26-R gives details. The Farval Corp.



12—CURRENT TRANSFORMER for indoor-outdoor use

Type BKM thermo-setting epoxy resin cast indoor-outdoor current transformers are designed for operating meters and instruments in single or three-phase circuits up to and including 600-v. Primary and secondary polarity markings are permanently molded into transformer casing to facilitate correct connections. Since secondary terminations are on top, it is possible to mount the units close together. A short circuiting device, which requires no tools to operate, is incorporated into this secondary terminal arrangement. Transformer can be mounted vertically, horizontally or inverted by means of a steel plate base. It comes in 1200, 1500, 2000, 3000, 4000-amp ratings. Allis-Chalmers Mfg. Co

13—INSULATION for pipes and vessel, stands 1800 F

Kaylo-20, a hydrous calcium silicate product, has the advantage of expanding slightly up to 1100 F, it is announced; immersed in a test furnace, at 1800 F, shrinkage is limited to about 1½ per cent. Kaylo-20 is produced in a fingernail pink color to distinguish it from company's standard Kaylo, which is effective up to 1200 F. Besides its heat control properties this insulation offers other advantages. According to manufacturer, it is light in weight, has enduring strength, is insoluble in water, and when dry, regains its original thermal efficiency and strength without shrinking or warping. It may be cut or sawed. The pipe insulation comes in thicknesses and diameters for pipe sizes from ½ to 39 in. The block is made 36 in. long, in standard widths to 18 in., and thicknesses to 3 in. Owens-Illinois Glass Co.

14—PROPORTIONING PUMP is compact, simply designed

Less weight, more compact size and simpler design are features of these pumps. They are equipped with company's Vane-Guide check valves. At normal discharge pressures (2500 psi) or less, the capacity range is said to be adjustable over more than 10-1 with repeatability of ± 1 per cent of rate. Other advantages announced are low initial cost, self-aligning connecting rod; self-venting reagent end and check valves, and low maintenance. Proportioneers, Inc.

15—LOAD BREAK SWITCH for use on 15-kv circuits

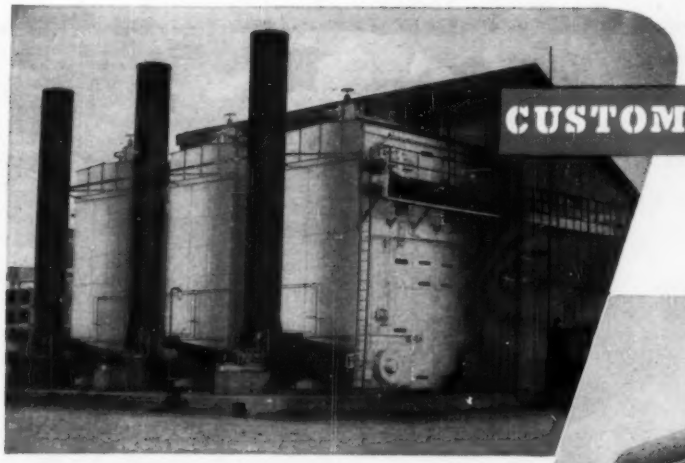
This air-insulated load-break switch has a rating of 500 operations interrupting 100 amp at 15-kv and a continuous current rating of 600-amp. It also meets NEMA standard of 40,000 amp momentary and 25,000 amp for four seconds. Switch is intended for use on 15-kv circuits with a basic insulation level of 95 kv. Design emphasis is also placed on minimum space requirements. Case matches appearance and heights of standard switchgear and dry-type power-center transformer cases, and is 34 in. wide, 48 in. deep, and a little over 90 in. high. Provision is made for connection to customer's lines at top or through the bottom. Westinghouse Electric Corp.

16—SPRAY VALVE incorporates parabolic plug

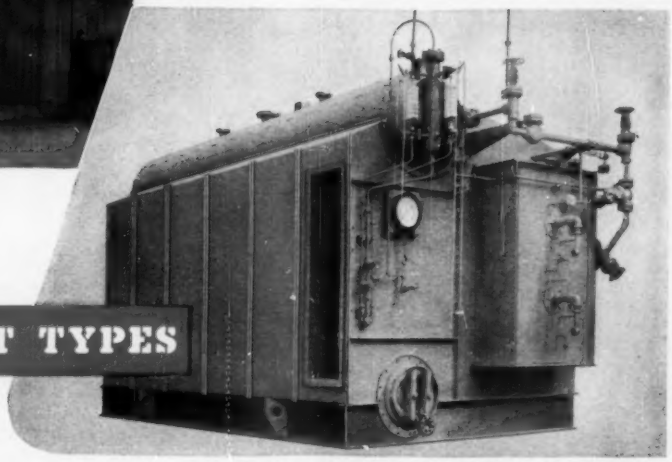
Designed for use with company's deaerating heaters and hot process softeners, this spray valve is said to greatly increase efficiency of these units. The main feature of the valve is a parabolic plug of special construction which is said to provide a constant flow angle under all conditions. By means of this plug an unvarying, even spray pattern is obtained with pressures and flow rates of 3 to 150 per cent of rating. Valve is made of corrosion-resistant stainless steel, is non-sticking, and said to require no maintenance. Graver Water Conditioning Co.

17—BOOSTER PUMP for industrial and municipal use

The development of two companies, Layne & Bowler Pump Co. and General Electric Co., the Verti-Line Submersible Booster Pump is designed for invisible and noiseless operation, greater safety, minimum space requirements, and low



CUSTOM BUILT TYPES



PACKAGE UNIT TYPES

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Types and Sizes for Every Power, Processing and Heating Requirement

Steam costs too high? Then it's high time to replace outmoded boilers with modern Vogt steam generators of the type and size to exactly fit in with specific operating conditions.

Vogt steam generators are designed to give maximum rating in minimum space, with high efficiency and low maintenance expense. They are available in bent tube types and straight tube, forged steel sectional header types for solid, liquid or gaseous fuels burned singly or in combination.

Package units range from 10,000 to 30,000 pounds capacity and custom built units are obtainable in the larger capacities. Many installations in successful operation are proof of Vogt's ability to give effective help in the solution of steam generating problems. *Bulletins may be had upon request. Address Dept. 24-BPE.*

HENRY VOGT MACHINE CO.

LOUISVILLE, KENTUCKY

Branch Offices: NEW YORK, CHICAGO, CLEVELAND, DALLAS, PHILADELPHIA, ST. LOUIS, CHARLESTON, W. VA.

For more data circle 528 on Post Card

maintenance. It embodies an oversize shaft, longer bearings with protective caps, mechanical shaft seal designed specifically for submerged service, and a choice of mixed-flow or radial-flow impellers. Its General Electric submersible motor has a larger oil reservoir and a spring-loaded resilient bag to permit the sealed motor to breathe with changing pressures and temperatures.

Most of the pumps in this line are assembled, ready for use upon installation. Standard models range from 5 to 150 hp with discharge head 50 to 500 ft and 100 to 4000 gpm capacity. They are suggested for typical sump, line booster, cooling tower, fire protection and barrel pumping installations. Layne & Bowler Pump Co.

18—WELDING CABLE is light and highly flexible

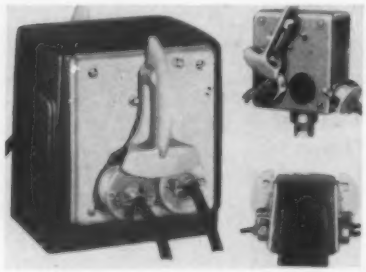
Type D866 lightweight aluminum welding cable is said to have an excellent flexibility and to be constructed to prevent kinking. The combined insulation and jacket of tough vulcanized rubber affords resistance to abrasion, impact, flexing and twisting. Cable not only provides safety and long service life, company points out, but also reduces operator fatigue. General Cable Corp.

19—ANALYSIS METER works on 6- and 12-v batteries

Model 956 Battery Analysis Meter gives overall readings on both 6- and 12-v batteries as well as on individual cells. According to manufacturer, the unit can be used on any battery produced to date and on all which may be developed in the future. This claim is based on the fact, company points out, that the instrument's test prods are both flexible as a unit and separable for any voltage pick-up points. Franklin Mfg. Co.

20—RECEPTACLE eliminates dangers of fire, explosion

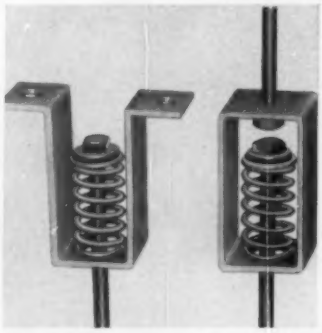
Many safety features are incorporated into these multi-purpose safelock receptacles, designed to eliminate dangers of fire and explosions caused by sparking in all hazardous areas. According to manufacturer, the extension cord sets



are locked into sockets and cannot be removed or inserted until the trip lever is actuated, which deenergizes each socket, thus eliminating possibility of arcing due to accidental removal of cords. Heavy duty mercury-to-mercury sealed connectors automatically operate as a circuit breaker. All units are for use with standard flush type receptacles and standard condulet housings for service up to 440-v. Bulletin 600 gives more details. Industrial Automation Corp.

21—PIPE HANGERS are heavy duty, high deflection units

Finnflex Types S and SC Steel Spring Vibration Hangers are designed to prevent transmission of noise and vibration from suspended equipment and to flexibly support piping systems. The units



consist of a helical steel spring enclosed in a steel housing. The springs are carbon-steel wire with cadmium plating to prevent corrosion. Company says they stand high temperatures without creep or permanent set, and low temperatures without increase in stiffness.

In both types available, the suspended load is transferred to the isolating spring by rods or bolts with washers that rest on the bearing plates which enclose the isolating medium. The top bearing plate is capped with a rubber isolation washer to minimize noise transmission; and at the bottom of the steel housing is a rubber damper washer to limit excursion at resonance. The units are intended for use where large deflections are required due to thermal expansion of pipe lines, where high and low temperatures are involved and where low disturbing frequencies are encountered. Rated load capacities range from 50 to 1000 lb. T. R. Finn & Co., Inc.

22—SENSING SYSTEM for precision speed control

Designed especially for use in precision automatic speed control equipment, this speed-change sensing system is claimed to provide high accuracy, flexibility, maintenance-free operation and low initial cost. The unit, which makes use of company's frequency responsive system, will react to a speed change as small as ¼ of 1 per cent of its top operating speed, it is said, and can be used at any speed up to 80,000 rpm. While completely automatic in operation, the unit also incorporates a tachometer indicator to provide operator with continuous speed indication. Weston Electrical Instrument Corp.

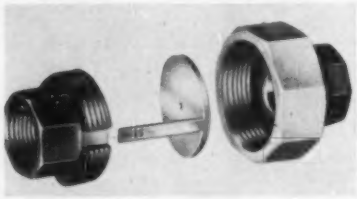
23—DEHUMIDIFIERS feature heavy construction, accessibility

Central station type sprayed coil dehumidifiers featuring heavy construction and ease of maintenance have a door on the air-output end to provide quick access to coils, drain trough and tank in that area. The coils themselves are removable from either the connection box side or from the air-intake or air-output end of the unit. Eliminators are also removable. Spray nozzles, float valve, strainer, coil face, drain troughs and tank are accessible via air inlet end.

The new units come in standard arrangements having one, two or three coils high and from four to eight coil rows deep. Finned tube length can vary from 2 to 10 ft; coil face area from 4 to 83 sq ft; and capacity from 2300 to 45,900 c/m. Face and by-pass dampers are available as an optional accessory. American Blower Corp.

24—ORIFICE UNION with plate identification tab

This 3000-lb orifice union for instrumentation and process control piping is said to eliminate errors in plate identification. A recent addition to company's forged steel fittings, its orifice size is plainly stamped on tab that protrudes



through a slot in end piece of union. Tab is an integral part of the stainless steel orifice plate. Orifice plate is easily removed when it is necessary to change flow conditions. Connecting pipes need not be pulled back any further than required to slip plate from between two union ends. Sizes, dimensions, and price information are contained in Data Sheet SU-1. Watson-Stillman Fittings Div., H. K. Porter Co., Inc.

25—FLUSH CLIP for fastening impaled insulation

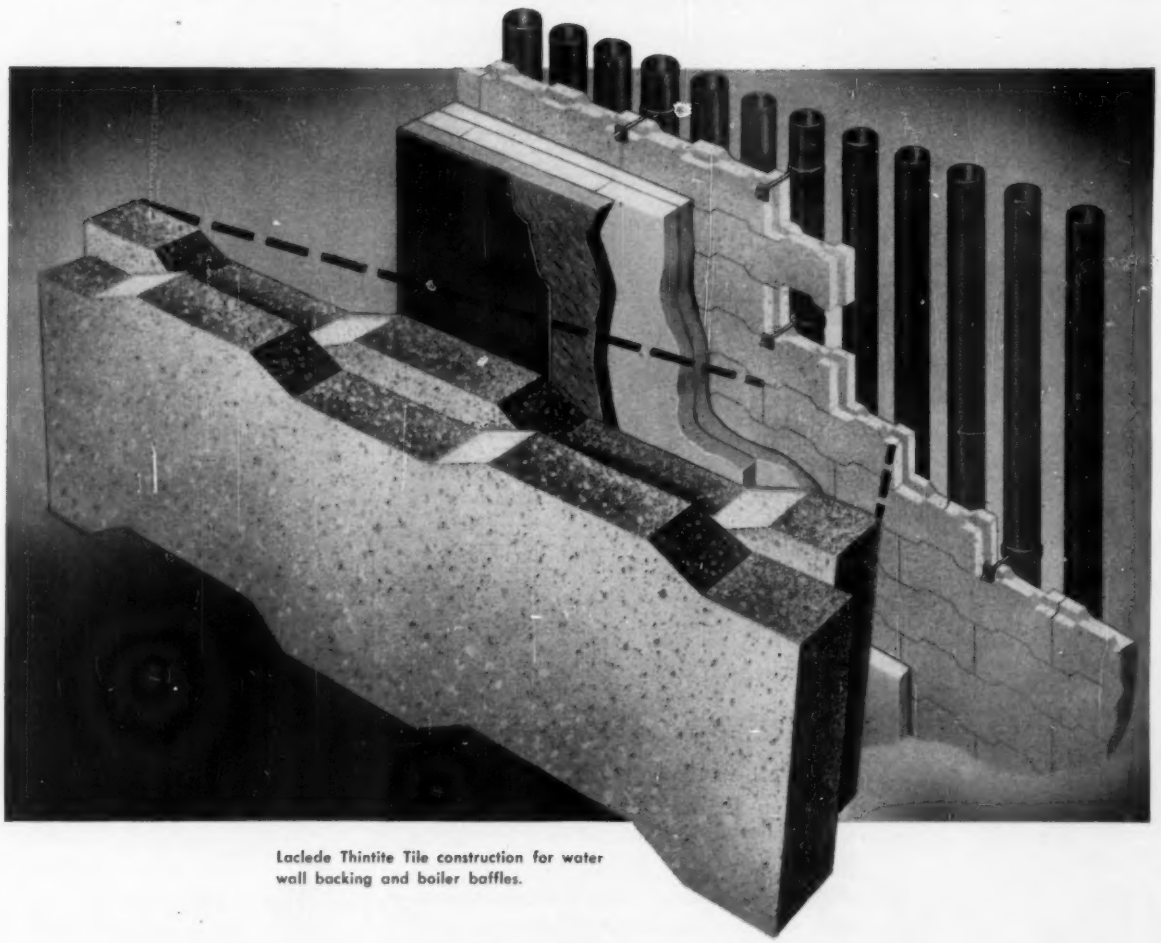
For use with impaled insulation, the Graham Flush Clip fits over the pin which is welded to the metal duct. When pushed home, clip is flush with insulation and assures a smooth, unbroken

surface on exterior of air conditioning duct insulation. There are no sharp projections. The flush clip safeguards personnel, company points out — it won't puncture or tear a vapor barrier. Clip is reported to operate ideally with company's Spintex insulation, plain and faced. Johns-Manville.

26—HAND PUMP for refilling the oil cups

Redi-Pump is a handy time-saving portable hand pump for refilling all types of oil cups and reservoirs directly from a gallon or larger container through a light flexible hose. It is also handy for dispensing oil to bearings, cutting tools, con-

New trends in the use of refractories



Laclede Thintite Tile construction for water wall backing and boiler baffles.

Reduce your costs, speed up installation with interlocking Laclede Thintite Tile

Thinner, lighter weight refractory furnace enclosures reduce maintenance and labor costs, weight and wall thickness and lower cost of new boiler settings.

Interlocking Laclede Thintite Tile offers *exclusive* advantages for water wall backing, as well as for boiler baffles and roof coverings. Tile sections interlock quickly and easily, reducing installation time and lowering cost per square foot. This interlocking design keeps the wall tightly sealed—reduces leakage to a minimum. Also, the Thintite wall is completely uniform—free from deformation or warpage.

Light weight Thintite Tile is machine-made of first quality fire clay to a single shape. The single shape permits use of Thintite for walls, baffles and roofs, thus reducing inventory requirements.

When you need boiler refractories, be sure to consider Laclede's Thintite Tile. Call your Laclede-Christy representative for all the facts.

LACLEDE-CHRISTY COMPANY DIVISION

LACLEDE-CHRISTY COMPANY — FOUNDED 1844 — Quality First

DIVISION OF H. K. PORTER COMPANY, INC. — HKP

H. K. PORTER COMPANY, INC.
2000 Hampton Ave. · St. Louis 10, Missouri
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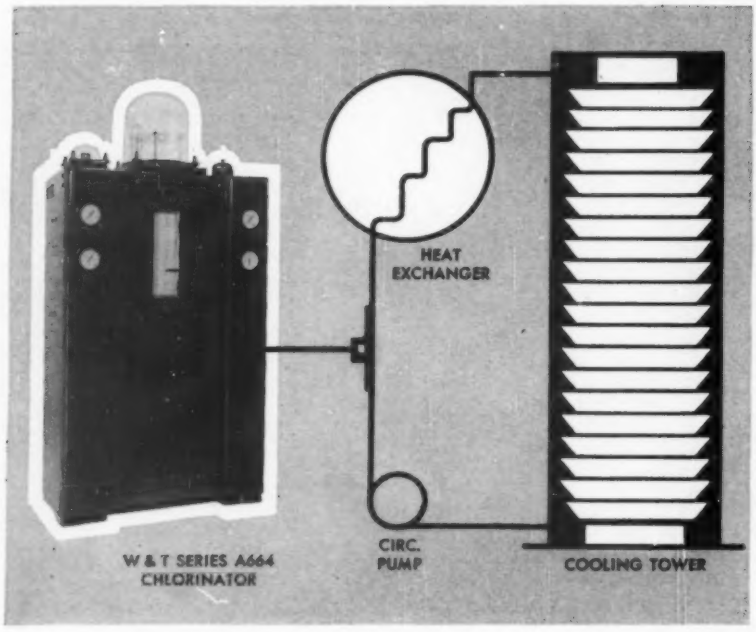
For more data circle 529 on Post Card

Slime Control...



...Chlorination of Cooling Water Circuits

Heat transfer losses caused by slime formation on condenser and heat exchanger water-side surfaces can be eliminated by chlorination of the cooling water. Water and air-borne organisms—the cause of slime formations—are effectively and economically controlled by Wallace and Tiernan chlorination systems.

The Wallace and Tiernan Series A-664 Chlorinator shown above is one of a complete line of W&T chlorination equipment, designed to give dependable chlorination at all feed ranges. It is used at large plants where cooling water chlorine requirements call for a durable high capacity unit.

We Invite Your Inquiries

Technical information on cooling water chlorination is available in our free booklet, RA-2061-C. Bulletins on chlorination of industrial process water and industrial waste treatment are also available. Write us for your copy.

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

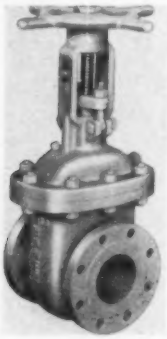
CD-40

For more data circle 530 on Post Card

veyor and drive chains, gears, pipe threading operations, spindle bearings on textile machinery. Because suction hose can be tapped directly to the container in which oil is purchased, there's no need to transfer oil to another container. Large reserve oil supply also eliminates constant stoppages to refill small oil cans. Redi-Pump dispenses oil in any direction or angle. Bulletin 44 gives more details. Trico Fuse Mfg. Co.

27—GATE VALVE designed to provide tight shut-off

Impenetrable shut-off, both on the upstream and downstream side of the wedge, is announced for this gate valve.



In addition to the metal-to-metal contact of the wedge and valve body seats, this valve incorporates a pair of Teflon packing seals which press tight against the wedge to form a seal. Stainless steel locking rings and seats make the valve impervious to corrosive fluids, manufacturer points out, and the replaceable stainless steel seat is lightly welded into the valve body to prevent leak-through. Hamer Valves, Inc.

28—VARIABLE SPEED PULLEY for use in limited space

The E-1350 ¼-hp Variable Speed Pulley, for limited space applications, is so designed that it can be mounted with belt take-off close to motor and/or reversed, in which case belt take-off is in an overhung position away from motor. Pulley delivers speed ratios up to 2 to 1. An A section belt is used. Maximum

bore is ⅝ in. with keyway. Bronze oil-impregnated bearings eliminate need for lubrication for life of pulley, says company; but where applications demand lubrication, the pulley is equipped with a pressure lubrication grease fitting on open end of bore, with grease channels

9:00 A.M.

10:12 A.M.

11:00 A.M.

11:45 A.M.

FOSTER GRANT'S EXPANDING PRODUCTION MEANT MORE STEAM... FAST

Fifth BROS Packaged Boiler ...goes from flatcar to foundation in 6 Hours

How to obtain more process steam with minimum time loss is built right into many companies' expansion plans. That's the way it was with Foster Grant Co., Inc., of Baton Rouge, La., a major styrene plastic manufacturer.

Back in '53, engineers of Foster Grant's petrochemical division set down the first two Bros Packaged Boilers. These went on the line, providing steam for the manufacture of FOSTA® styrene products and FOSTARENE® polystyrene. In the plastic boom, more steam was needed, so another Bros unit was installed and, recently, two more. The timed transfer of one of them from flatcar-to-trailer-to-foundation took but six hours.

...These units operated in series, provide a total steam capacity of 150,000 lbs. per hr. Each unit's design pressure is 600 lbs.

HERE'S REAL OPERATING ECONOMY

Because of the flexibility of packaged boilers operating in multiples, you exercise close control over steam requirements, keeping fuel costs down. Also, varying load conditions are easily accommodated. So there's real satisfaction to Foster Grant in having maximum operating efficiency, regardless of load conditions.

Design features, fast installation and operating economy make the Bros Packaged Boiler the logical choice in your expansion plans. Capacities range from 4,100 to 30,000 lbs. of steam per hour. Gas or oil fired or combination. Choice of manual, semi or fully automatic controls. Expertly designed boilers by boiler experts since 1882.

Write today for the factful Bros Packaged Boiler Catalog WT-7; no obligation, of course.

BROS

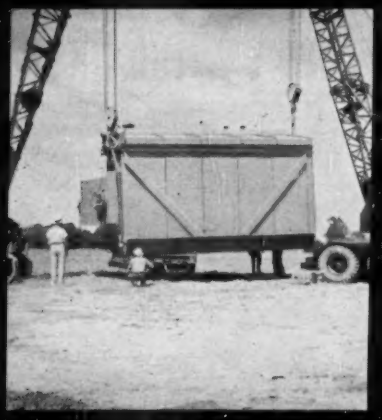
POWER DIVISION

WM. BROS BOILER & MFG. CO.

1057 Tenth Avenue, S.E.

MINNEAPOLIS 14, MINNESOTA

DESIGNERS AND MANUFACTURERS OF WATER-TUBE BOILERS, 2, 3, and 4 DRUM AND PACKAGED DESIGNS. AUXILIARY EQUIPMENT AND FULL LINE OF INDUSTRIAL STOKERS



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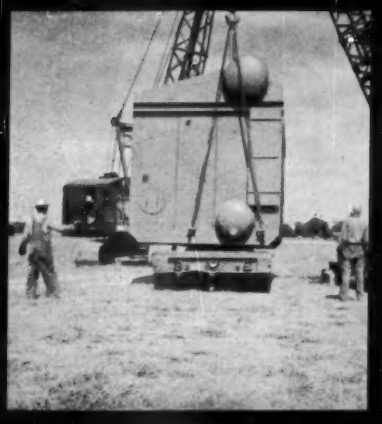

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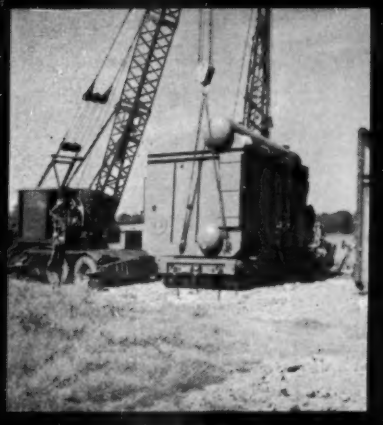

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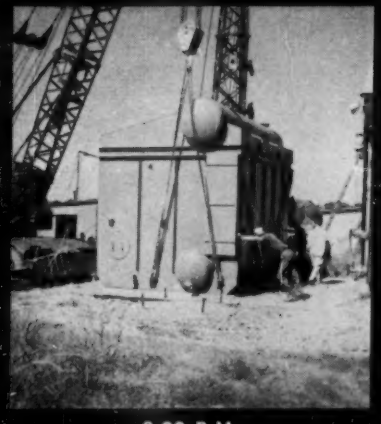
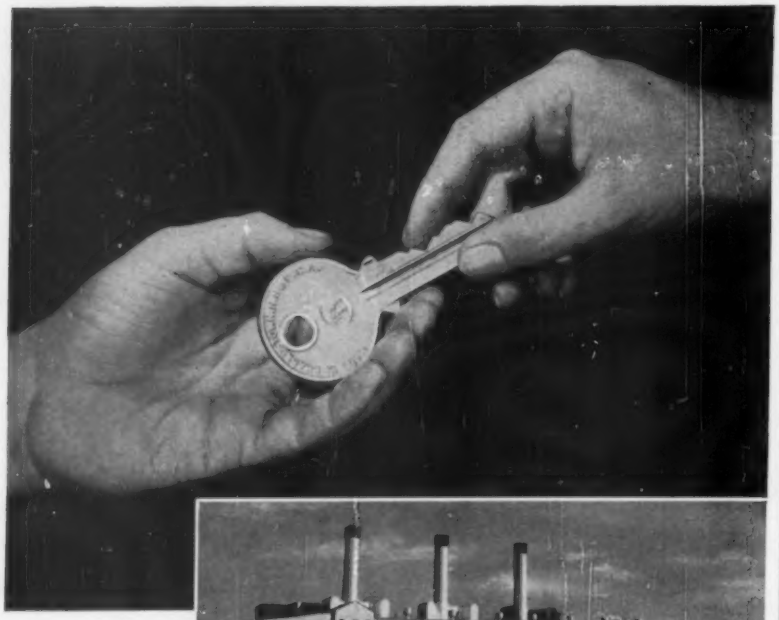
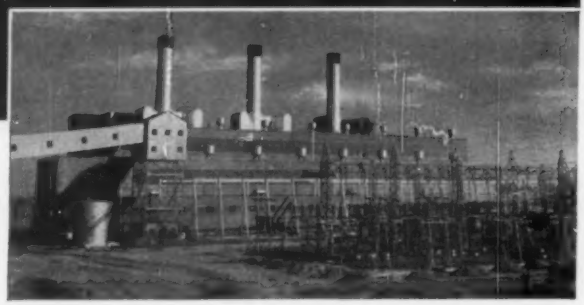


3:00 P.M.

WHY A TURN-KEY PROJECT IS BEST FOR YOU





A Turn-Key project is a "packaged" service that combines engineering and construction in a single contract . . . and that may include other services such as preliminary investigations, studies and site selection, procurement of materials and equipment, initial operation of the finished plant.

Advantages to you:

LESS COST: Who is better qualified to construct a project than the firm that designs it? In a Turn-Key project one organization performs both engineering and construction services; details are handled quickly, efficiently—therefore more economically.

LESS TIME: Excavation can be made and foundations started several months prior to the release of the Engineer's completed design drawings and specifications. Construction follows blue prints—promptly. This scheduling of design and procurement to meet construction requirements permits the project to advance in an unbroken sequence—setting the stage for a faster delivery of the completed plant.

MORE SERVICE: One contract gives you *complete* service—no question about responsibility. Thus you have better control and more closely integrated planning.

We offer you engineering and construction services separately but suggest you consider combining them into a Turn-Key project that will save you both time and money. Write today for this free booklet describing the advantages in detail.

POWER • AVIATION • PETROLEUM • TEXTILES • INDUSTRY

The Kuljian Corporation

engineers • constructors

1200 North Broad Street • PhHadelphia 21, Penna.

For more data circle 532 on Post Card

running to bearing surfaces.

In this pulley, the outer sheave is keyed to inner shaft with a heavy-duty key and held in position by a screw. Sliding shaft, which is part of inner sheave, is precision ground for close fit on oil-impregnated bearings which are pressed into outer sheave prior to assembly. Pulley can be used with company's 135 variable speed base, the 200 tilting base or any other sliding base on shifting mechanism desired. Overall dimensions are $3\frac{5}{16}$ in. length by 3 in. diameter. Weight is 26 oz. Lovejoy Flexible Coupling Co.

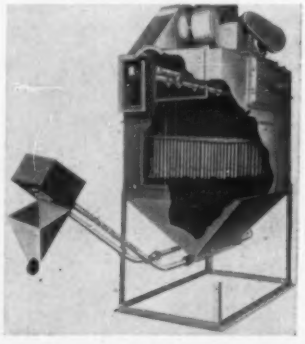
Reader Service Cards on pages 121–122 make it easy to get further information on any of these products. Just circle the item numbers of the products you want to know more about.

29—POLE-TYPE TRANSFORMER is reduced in height

Height reductions — averaging more than 5 in. — are featured in this company's new pole-type distribution transformers in ratings from 25 to 100 kva. The height cuts make possible the mounting of higher rated units using existing bolt holes and keeping adequate clearance from overhead wires. Greatest single height cut was made on the 100-kva unit — from 55 to $45\frac{1}{2}$ in. — making it only $1\frac{1}{2}$ in. taller than the former $37\frac{1}{2}$-kva transformer and only one half inch taller than the former 50-kva unit. General Electric Co.

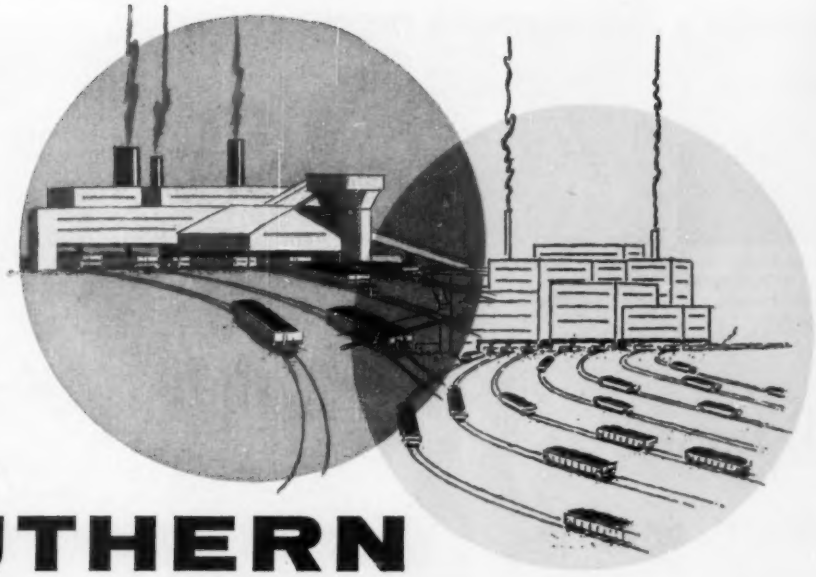
30—GAS SCRUBBER removes low micron dust, fumes, odors

Reported to remove microscopic solids, fumes and odors from exhaust gases at 99 per cent efficiency, the Type A Hydro Precipitator Scrubber can be used where impurities are encountered of extremely low and even sub-micron particles. It collects dust by hydro-compressing ex-



haust gases through a system of multiple tubes into a water chamber. This produces a scrubbing action. The violent water agitation set up causes secondary pressure turbulence and additional scrubbing action in the tube chamber. The scrubber comes in 15 sizes for capacities from 500 to 40,000 cfm. Sludge can be removed constantly or intermittently by manual or other means.

Dust-laden gases can be pre-wetted



In addition to coals currently produced and sold

SOUTHERN

is now **the marketing organization** for

PEABODY COAL COMPANY

supplying through one dependable source the combined tonnage of diversified, high quality INDUSTRIAL, COMMERCIAL and DOMESTIC COALS mined by and for these widely known producers.

●

27 completely mechanized mines—25 million tons annual production from leading seams and districts in EASTERN and WESTERN KENTUCKY, OHIO, INDIANA, ILLINOIS, IOWA, OKLAHOMA, ALABAMA and MISSOURI.

●

Low cost recovery, precision preparation, tremendous reserves and fast, economical transportation offer you unparalleled values in uniform quality, accurate application and dependable supplies.

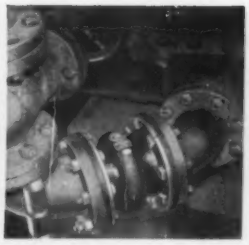
Shipment over 12 major railroads; by barge through inland riverways via Yankeetown Dock on the Ohio River, and to all ports on the Great Lakes through Rail-to-Water Transfer Facility at Chicago and the Duluth and Superior Docks.

Southern Coal Company, Inc.

GENERAL OFFICE: 333 N. MICHIGAN AVE. • CHICAGO 1, ILL. ● OFFICES IN: LOUISVILLE, MEMPHIS, NASHVILLE, ST. LOUIS
SINCLAIR COAL CO., KANSAS CITY MO., Western Representative

For more data circle 533 on Post Card

Garlock rubber expansion joint on vacuum line between turbine and condenser



Expansion joint operating on suction side of centrifugal pump handling condensate from condenser

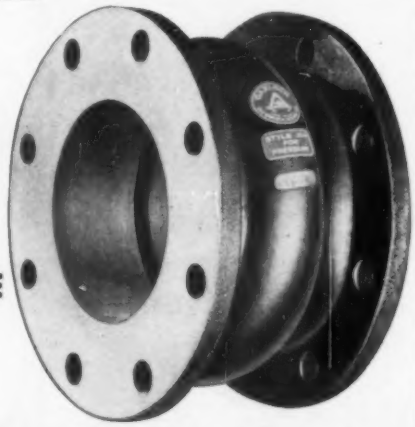
Expansion joint operating on condensate pump discharge line

STOP NOISE,

VIBRATION, and

FLANGE BREAKAGE

WITH



GARLOCK EXPANSION JOINTS

GARLOCK rubber expansion joints absorb vibration and compensate for linear expansion and contraction of pipe lines. They stand up under repeated flexing—do not crack or fracture.

These flexible joints are used to prevent transmission of sound and to absorb vibration in air conditioning and water lines in commercial, institutional, and industrial buildings. Wear and tear on pipe flanges is reduced to a minimum.

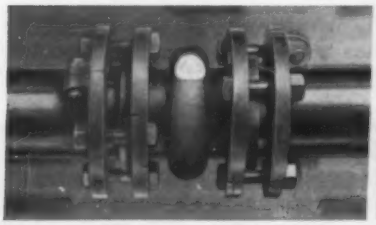
GARLOCK **Rubber Expansion Joints** are made for all pipe sizes ¾" to 72". **All "Teflon" Joints** or **Rubber Joints with Teflon liner** are made for chemical service; **Neoprene Joints** for oil service.

For complete information, write today for Folder AD-137.

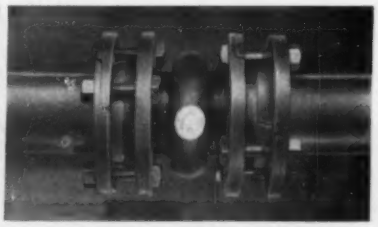
THE GARLOCK PACKING COMPANY, PALMYRA, N. Y.

Sales Offices and Warehouses: Baltimore, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, Los Angeles, New Orleans, New York City, Palmyra (N.Y.), Philadelphia, Pittsburgh, Portland (Ore.), Salt Lake City, San Francisco, St. Louis, Seattle, Spokane, Tulsa

In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ont.



Garlock expansion joint applied to pipe made by Haveg Corp.



Garlock expansion joint applied to pipe made by The Duriron Co., Inc.

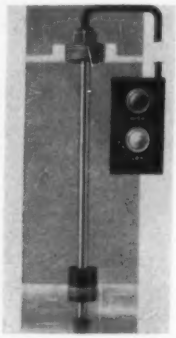
For more data circle 534 on Post Card

and pre-cooled in the plenum or entry chamber. This, plus constant recirculation of water, permits operation of the scrubber at high temperatures. Constant flushing of interior acts to prevent build-up of solids on internal surfaces and components. Water consumption is low because the scrubber operates on a recirculating system, and makeup water is controlled automatically. The unit can be used indoors or outdoors.

The scrubber consists essentially of a rectangular shaped housing containing a plenum chamber, a multiple-tube section, water tank underneath housing, a dewatering filter and an exhaust fan mounted on top of the housing. It is self-contained, with walls, top and bottom of steel construction. When required, it can be built with special metals or plastic materials for service with corrosive or toxic gases. The Johnson-March Corp.

31—LEVEL INDICATOR adaptable to many requirements

Model LI-800 can be supplied to show high and/or low level and, if desired, any number of intermediate levels. In operation, changes in the liquid level cause a foam plastic float to move up

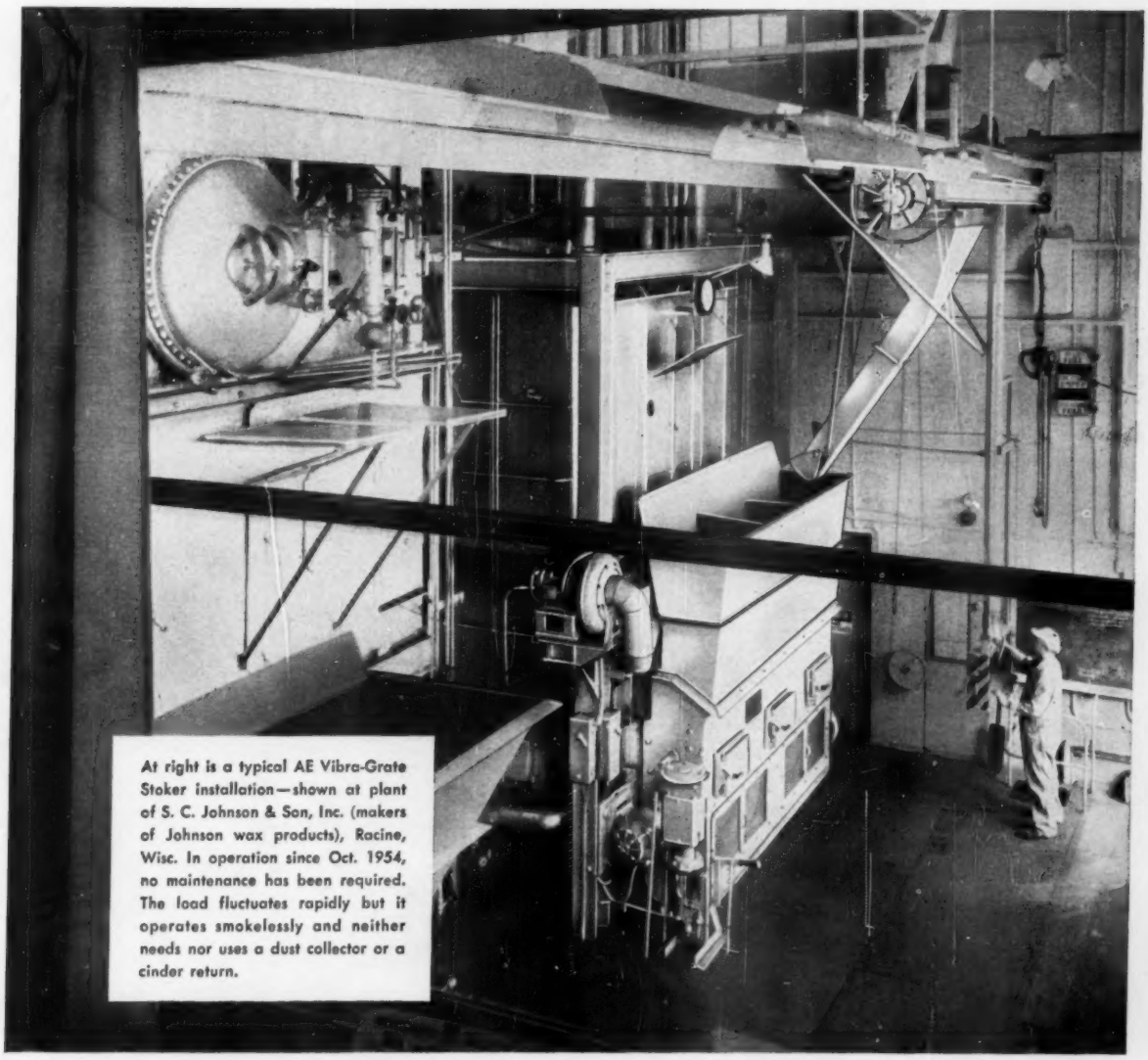


or down the bronze indicator stem. As the float passes pre-selected points, hermetically sealed switches are actuated. These, in turn, may be arranged to operate indicating or warning lights on an instrument panel, or other signal devices. With suitable relays, pumps or other power-driven equipment can be started or stopped automatically. Since the head assembly of this indicator is a standard pipe plug, the instrument is easily installed, says company, and wiring is also simple. The Gems Co.

32—COUNTER DIAL is direct reading instrument

The Amer-Dial direct reading counter dial can be used with multiturn devices such as potentiometers, microwave oscillators and amplifiers, wavemeters, or any other hand or servo operated mechanism, where direct reading to hundredths of a turn is desired. Two features contribute to speed and easy operation: it has a driving ratio of 1½ to 1, and it allows complete continuous rotation, in either direction, without obstruction. It has a four-digit counter and affords readings up to 9999, with up to 100 turns. The counter wheels are white with black numbers. The Amer-Dial is described as a compact unit of black anodized aluminum, measuring 2¼ in. diam, 1¾ in. in depth. Amerac, Inc.

— more Bulletins on page 134



At right is a typical AE Vibra-Grate Stoker installation—shown at plant of S. C. Johnson & Son, Inc. (makers of Johnson wax products), Racine, Wisc. In operation since Oct. 1954, no maintenance has been required. The load fluctuates rapidly but it operates smokelessly and neither needs nor uses a dust collector or a cinder return.

Write us for latest performance report on this remarkable stoker...the

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Made by the makers of the Taylor and Perfect Spread Stokers

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AE products are: Taylor, Perfect Spread and Vibra-Grate Stokers, Hele-Shaw and Hydramite Fluid Power, Lo-Hed Hoists, Lo-Hed Car Pullers, Marine Deck Auxiliaries.

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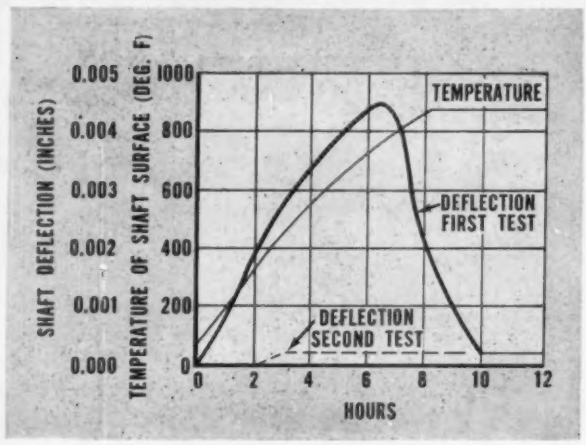
Taking the Bends out of



FURNACE WALLS ARE LOWERED around generator rotor for heat stability test. Chart shows shaft deflection before and after stabilizing treatment.

Turbine and Generator Rotors

General Electric's careful manufacturing procedures help assure thermal stability before units leave the factory

Large steam turbine-generators must be practically free of vibration in operation if long life and minimum maintenance are to be achieved. Continued smooth operation requires both good design and extreme care during manufacture and assembly of rotor components.

AN ESSENTIAL REQUIREMENT in manufacturing is to obtain maximum thermal stability of the rotors. A thermally unstable rotor will bend slightly when the turbine-generator is at operating temperature, introducing mechanical unbalance which may cause the unit to vibrate objectionably at running speed.

This type of instability may be caused by several factors. These include nonhomogeneity of the forging material and machining strains or distortion of the surface crystals during machining operations. And in generators, rotors may have slight variations in dimensions of slots and windings or dissymmetries in the ventilation circuit.

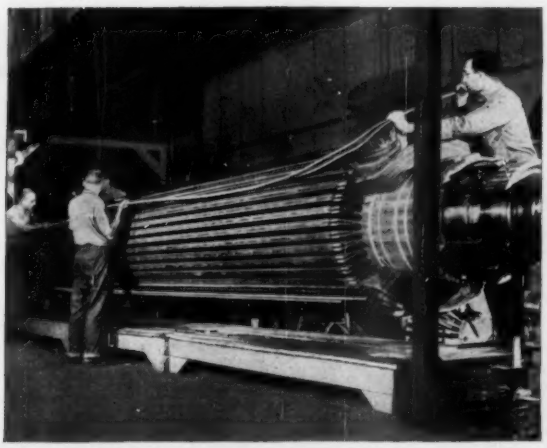
General Electric has developed standard manufacturing procedures to help make sure that rotors are thermally stable before leaving the factory.

EARLY IN THE MANUFACTURING CYCLE turbine rotors which will be subjected to high operating temperatures, and large high-speed generator rotors are tested for thermal stability. If necessary, they are either "cured" in a heat lathe or rejected. In addition, careful manufacture, close inspections during various stages of rotor assembly, and factory tests at operating speed gives assurance of maximum thermal stability—a feature you can depend on with General Electric turbine-generators. If you would like more information on this subject, contact your nearest G-E Apparatus Sales Office or write for bulletin GER-767, "Balancing Turbine-Generator Rotors." General Electric Company, Schenectady 5, N. Y. 234-30

Progress Is Our Most Important Product

GENERAL ELECTRIC

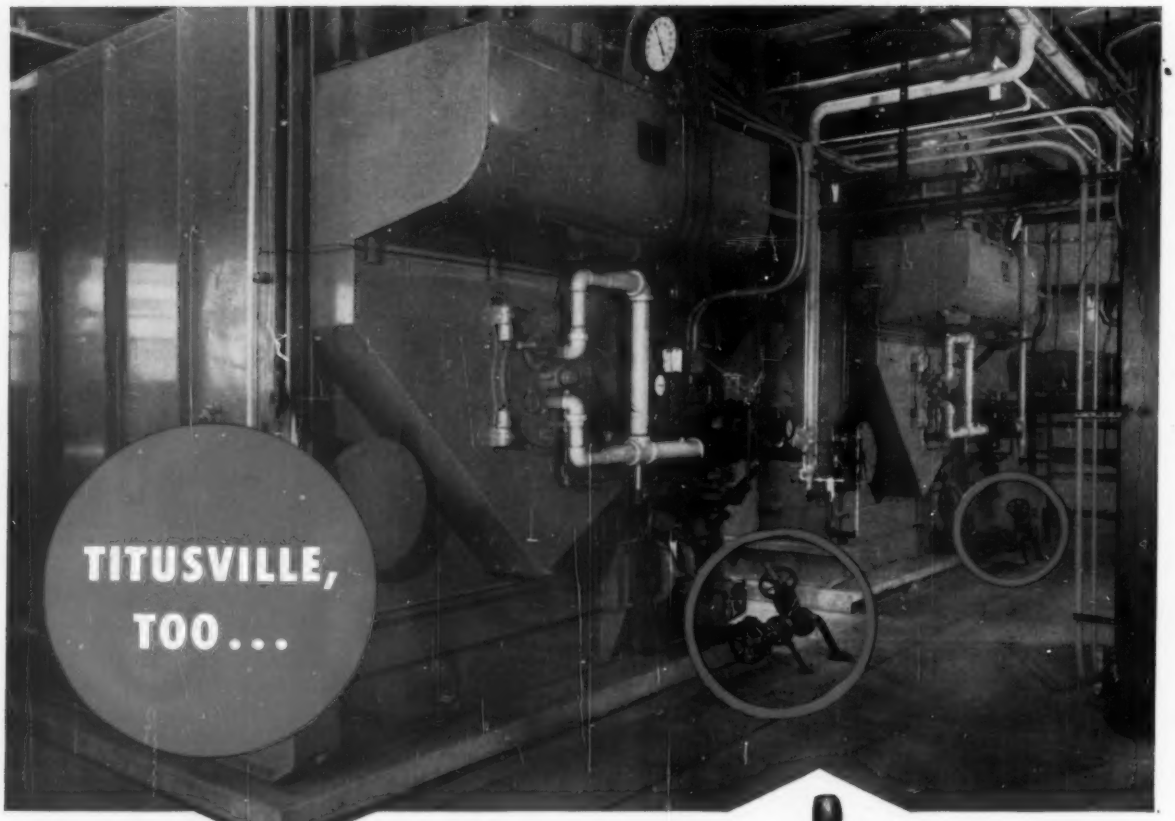
ALTERNATE SLOT MILLING of generator rotor compensates for minor slot variations—provides symmetry.



CAREFUL WORKMANSHIP during manufacture and assembly of rotor windings helps equalize heat and temperature distribution, which contributes to thermal stability.

PRECISION BALANCE of generator rotors helps assure vibration-free operation.

For more data circle 536 on Post Card



...SELECTS YARWAY BLOW-OFF VALVES FOR PACKAGE BOILERS

Take a look at the blow-off valves on this new Titusville Iron Works WTP package boiler—they're Yarway Seatless.

Titusville, along with most other manufacturers of water tube package boilers selects Yarway Seatless Blow-Off Valves to make *good* package boilers *better*.

Yarways seal drop-tight—have no seat to score, wear, clog or leak—combine good design with latest metallurgical improvements.

Whatever make of package boiler you buy, specify *Yarway Seatless* for the blow-off valves. *More than 16,000 boiler plants use Yarway Blow-Off Valves—some for 35 to 40 years!*

Write for full details in Bulletin B-426.

YARNALL-WARING COMPANY
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BRANCH OFFICES IN PRINCIPAL CITIES

Yarway Type "B" Seatless Tandem, Blow-Off Valve. Note balanced sliding plunger design with no seat to score, wear, clog or leak. Pressures to 400 psi.

YARWAY BLOW-OFF VALVES

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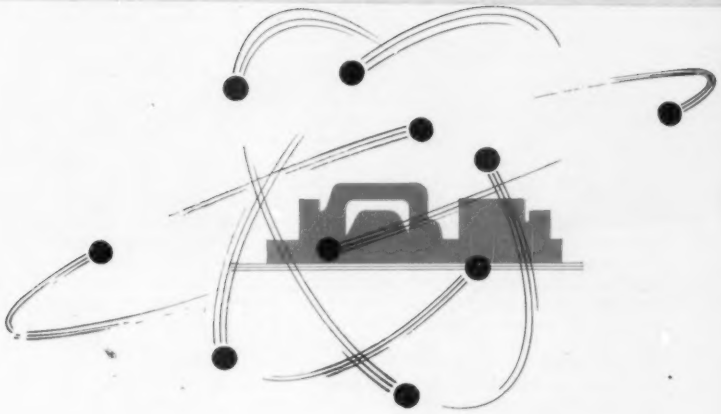
Power Development and the Peaceful Atom



WHATEVER else we may lay claim to in looking back at the year 1955, every citizen of the United States can take justifiable pride in the part this country played in the Atoms-for-Peace Conference at Geneva last summer. The results of that great meeting exceeded everybody's expectations. More than ever it brought home to us the vital significance of atomic energy in our civilization.

There seems to be little doubt that in the years and decades to come, the period, from mid-1954, when the Atomic Energy Act of 1954 was drafted, to the International Conference at Geneva in mid-1955, will go down in history as Year One of the Age of Nuclear Power.

No reasonably informed person today can seriously question the future development of atomic power. The technique of generating power from the energy of nuclear fission is well on the way to being worked out, with a number of large power stations actually under design or construction. Among other things, the completion of the first 25,000-mile run of the submarine Nautilus on her initial fuel charge, is dramatic evidence that nuclear power plants can be made safe and reliable. What still remains is to prove their economic feasibility.

The answer to this problem will vary in different areas because of local conditions but with uranium selling for from $15 to $30 a gram, equivalent on a fuel-cost basis to power at 2 to 4 mills per kwh, it comes close to competing with conventional fuel even in our low cost coal regions. Because of higher fuel costs, however, it is quite likely that nuclear power will be developed on a large scale in Britain before it is on this side of the Atlantic.

Nevertheless, nuclear power is as inevitable in this country as in England because of the almost exponential rate of growth in our use of electric power. As indicated in the following pages, by the year 1970 the U. S. will have an installed generating capacity of 320 million kilowatts, and we will be using almost a billion and a half kilowatthours per year. Th's is only 14 years from now.

What the demand for power might be, say in the year 2000—only 44 years ahead—is anybody's guess, but, barring a hydrogen war, on the basis of present rate of growth, it appears that we will be needing some *two billion kilowatts* of generating capacity, roughly 20 times that installed at present. In terms of what this means to the power industry, it spells only one thing—ATOMIC POWER.

As our coal, oil and gas resources become depleted it will become economically feasible to draw more and more upon nuclear energy for the source of our power. The Peaceful Atom looms large in the future of power development.

1955 — Year One of Commercial

Last year was the first year in which plans were made to build nuclear power stations with private capital. Consolidated Edison led the procession with its announcement of the Indian Point Station. Then Commonwealth Edison followed with its proposed Dresden Station. Finally, commercial atomic power was fed into the lines of utility systems both at Arco, Idaho, and at West Milton, N. Y.

By ANDREW W. KRAMER
Editor, POWER ENGINEERING

JUDGED from almost any standpoint, the year 1955 will go down in history as a year of great advance in the development of nuclear science but it was of special significance to the power industry because it was the year which ushered in the first *commercial* nuclear power. On March 22, Consolidated Edison of New York made history by filing with the AEC the first license application for a central-station nuclear power plant to be built *without* government funds. Shortly afterward, to meet the April 1 deadline set by the AEC for its Power Demonstration Reactor Program, three more applications were made to build large nuclear power plants. These were the Yankee Atomic Electric Co.'s proposal to build a 100,000-kw pressurized water plant, Atomic Power Development Associates' (Detroit Edison group) plan to construct a 100,000-kw fast breeder reactor plant, and Commonwealth Edison's application to build a 180,000-kw boiling water reactor plant near Chicago. Added to these is the 75,000-kw sodium-graphite reactor plant proposed by the Consumers Public Power District of Columbus, Neb., and the 22,000-kw boiling water reactor plant to be built near Minneapolis, Minn., by the Elk River Cooperative Power Associates.

Of course, none of these plants are even in the initial stages of construction and it will be some 3 to 4 years before they are scheduled for completion. All of them, however, are to be built solely for the production of commercial atomic power. But *commercial* nuclear power was produced by two installations last year which had been designed for other purposes.

The first of these occasions was on July 17, when electricity produced by heat from the experimental boiling water reactor by Argonne National Laboratory at the AEC's National Reactor Testing Station in Idaho was transmitted to the little town of Arco 20 miles away. A 3500-kw turbine generating unit had been installed to produce the electricity. This, therefore, became the first community in the United States to receive its *entire* supply of power from a nuclear source. When the reactor power was cut in, the utility lines normally supplying power to Arco from the Utah Power and Light Co. were disconnected. Then the entire community of 1200 inhabitants depended solely on nuclear power for more than one hour.

The Arco demonstration occurred just one day before atomic electric power went on the line into the public utility system of the Niagara Mohawk Power Corp. at West Milton, N. Y. This was on Monday, July 18. In this case the steam for driving a 12,500-kw turbine generator was produced by the prototype reactor for the submarine Seawolf which had been built at the Knolls Atomic Power Laboratory. Under an arrangement between the AEC and Niagara Mohawk, some 10,000-kw of "dump" power was sold to the utility at 3 mills per kwh.

The Geneva Conference

The high point in the year's development of nuclear power was, of course, the Geneva Conference itself. The Geneva Conference was important not so much in that it brought to light a vast amount of material which had previously been classified, but for the spirit that prevailed at the meeting. Here, for the first time, scientists and engineers from all the principal countries of the world gathered to discuss openly and with very little restriction, all the various problems involved in the development of atomic power.

The impact of the Geneva Conference, together with the sudden burst of activity on the part of four private utility companies in scheduling large power reactors in addition to five government power reactors and five university research reactors, leaves little doubt as to the future of atomic power. Because all the U. S. plants are scheduled for completion by 1960, it is possible that we will be ahead of the British, despite the United Kingdom's bold plans to build 16 reactors in the next ten years.

Of much greater importance than who is ahead, however, is what will these gigantic efforts bring us? There is little doubt, now, that by 1960 we will have the answer to the constantly repeated questions — "When will we have economic nuclear power, and in what parts of the world?"

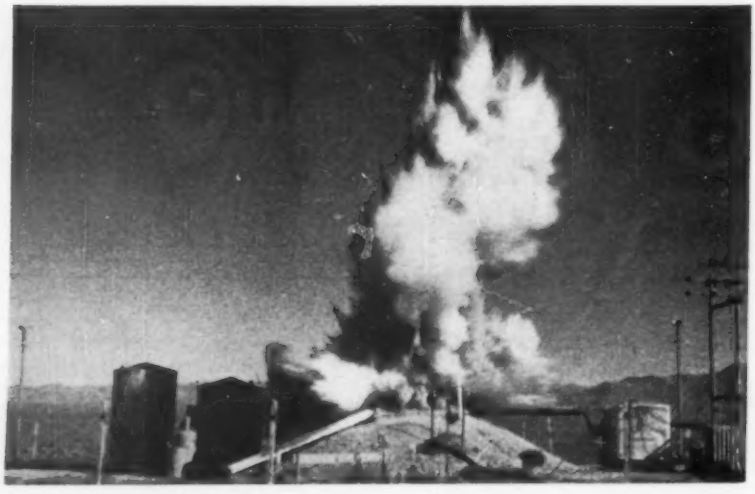


Fig. 1. Water was hurled violently from Argonne National Laboratory's experimental boiling water reactor, Borax-I when the reactor was permitted to run away in a series of experiments conducted to show the inherent safety of this type reactor

Nuclear Power

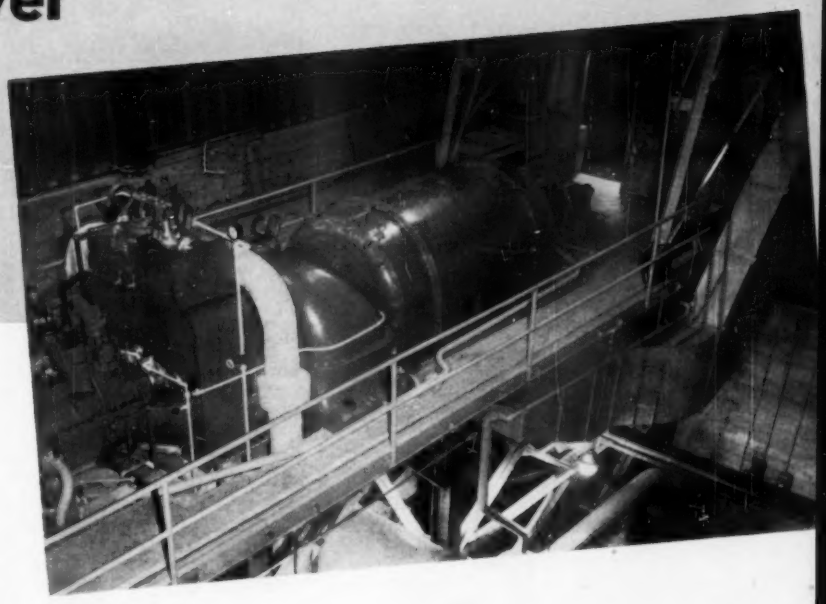


Fig. 2. A view of the first turbine generator unit to produce commercial atomic electric power in the United States. This 3500-kw unit at Argonne's Borax reactor facility in Idaho delivered electric power to the town of Arco on July 17, 1955

"What type of reactor will be best for economic power?"

It is inevitable that we will have the answers to these questions by 1960 because by that time we will have data on the costs of construction and operation of all kinds of reactors. Of course, we will find that there is probably no *best* type of reactor for all purposes, no more so than we can say that there is a *best* type of conventional power plant. Those of us in the power industry know that the design of a power station depends upon many different factors, and so it will be with nuclear power plants. Indeed it is possible to list an almost unending number of types of reactors. Dr. Alvin Weinberg, Director of the Oak Ridge National Laboratory, made up a table of the various elements involved in reactor design, somewhat as shown on this page, listing fuel, fertile material, moderator, coolant, neutron economy, and geometry. Under each heading he lists the different items, four for fuel, two for fertile material, six for moderator, six for coolant, etc. Multiplying all these together, we get

$$4 \times 2 \times 6 \times 6 \times 3 \times 2 = 1728.$$

So, we have at least this number of possible types to choose from. It is not surprising, therefore, that the problem of reactor design has been confusing to many who do not understand the basic principles of their operation. Various countries are geared to certain designs because of scarcity of materials and fuels. Thus, most European countries base their designs on the use of natural uranium as fuel since they do not have enriched uranium available. Different environmental situations affect reactor design and the use of nuclear energy. England, for example, has an energy crisis right now. Her coal is becoming increasingly difficult and more costly to mine and with an expanding electrical load has to act fast. So the English are determined to develop nuclear power plants as rapidly as possible. The urgency of the situation calls for simple and reliable nuclear power plants using natural uranium. Hence, the large gas-cooled (carbon dioxide) reactors at Calder Hall now under construction. These are two 50 to 100-Mw graphite moderated plutonium producing reactors, comprising one station. Power will be taken from these units as a byproduct. Six more such reactors in three stations will also be built immediately as *chinese* copies of the Calder Hall plants. Two of these additional reactors are to be installed in Calder Hall and the other four at Chapel Cross.

Power Reactor Designs

Of the various reactor designs presented at the Geneva Conference, from an international standpoint Russia's pressurized-water graphite reactor was probably of greatest interest because for the first time it gave actual details of Russia's reactor technology. This station comprises a 30-Mw reactor and a 5000-kw turbine generator unit. It uses 5 per cent enriched uranium as fuel. The plant went into operation in June 1954 and by last summer had produced some 15 million kilowatt hours. Curiously enough, the Russian reactor has a burnup of only 0.3 per cent which is equivalent to 3000-Mw days per ton.

Of all the reactors described at Geneva, the one of great interest to the Americans from a technical standpoint was the Canadian Nuclear Power Demonstration (NPD) reactor being built at Des Joachims, Ontario. This 10–20 Mw (electricity) uses natural uranium and is cooled with D_2O and also moderated with D_2O. This reactor is unique in that the D_2O coolant, at 500 F when it leaves the reactor, is kept liquid by 1200 or more psi and gives up its heat to H_2O in two steam generators to make steam that goes to the turbogenerator. The D_2O moderator is also circulated and is not heated appreciably, being circulated through heat exchangers to keep its temperature at 60–260 F. Another unique feature is that the reactor may have no control rods, the control being achieved by varying the quantity of D_2O moderator in the core. As Dr. Walter Zinn, Director of Argonne National Laboratory pointed out this reactor is one of the most promising developed so far out of the U. S. and if the Canadians can operate it at a burnup of 3 per cent, equivalent to 30,000-

Table listing various elements and conditions in the design of nuclear reactors

Fuel	Fertile Material	Moderator	Coolant	Neutron Economy	Geometry
Nat. U U-235 U-233 Pu-239	Thorium Uranium	H_2O D_2O Be Be-O Nothing etc.	Gas H_2O D_2O L-M Hydrocarbons etc.	Fast Int. Thermal	Heterogeneous Homogeneous
4	2	6	6	3	2

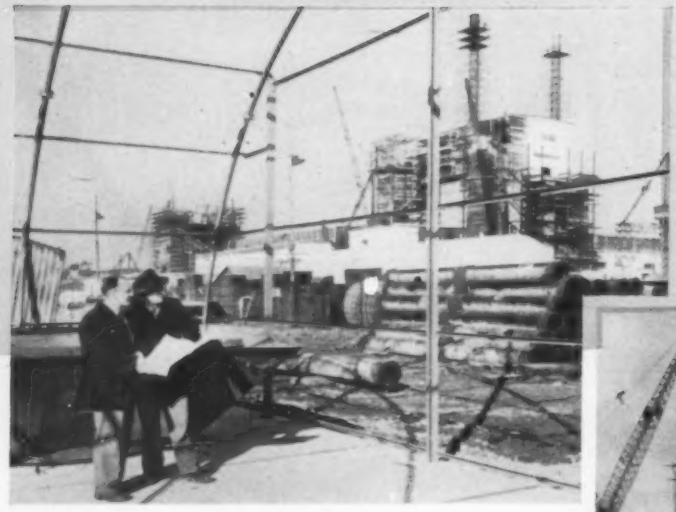
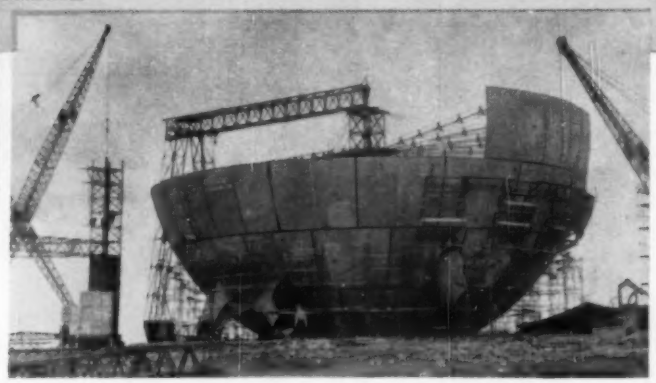


Fig. 3 (Left) This is a view of Britain's Calder Hall Station under construction. It is scheduled to go into operation in 1956 and will probably be the first large atomic power station in the free world to go into continuous service

Fig. 4 (Below) Britain's second atomic power station under construction at Dounreay, Scotland. This 135 ft steel sphere, will house the fast breeder experimental reactor which will produce more atomic fuel than it consumes



Mw days per ton it will have great possibilities. This is ten times the rate of burnup in the Russian reactor.

U. S. Reactor Development

The successful development of the pressurized water reactor for the submarine Nautilus and the relative abundance of enriched uranium on this side of the Atlantic has had a marked effect on our choice of reactors for the first nuclear power plants in the United States. Both the Shippingport and the Consolidated Edison plants as well as the proposed plant for the Yankee Atomic Electric Co. in Massachusetts are of the pressurized water type, using enriched fissionable material as fuel.

The Shippingport reactor, basically, is similar to the reactor on the Nautilus but unlike the reactor on the Nautilus, the Shippingport reactor is of the regenerative type. As already mentioned, a vast variety of reactors are possible but the most important breakdown on reactors is in how they use their fuel, and there are three categories. First there is the nonregenerative type or *burner-upper* which uses up all the fissionable fuel without creating any new fuel in the process. The reactor for the Nautilus, so far as can be learned, is of this type.

Second, is the regenerative type or the *stretcher-outer* which replaces part of the fuel it consumes by changing fertile material into fissionable fuel.

Finally, there is the *breeder* reactor which creates as much, *or more*, fuel as it consumes. The breeder reactor is the most glittering dream of all because it promises to make available for fission all the natural uranium and thorium there is in the world.

Beside the Consolidated Edison and the Commonwealth Edison plants, three other proposals submitted under the AEC's Power Demonstration Program are under study. Perhaps the most ambitious and daring of these is the 100,000-kw fast breeder reactor proposed by the company group headed by Detroit Edison Co. It would cost an estimated $45,000,000. The fast breeder contains very little moderating material, the fission process being maintained by high energy (fast) neutrons, and more nuclear fuel is produced than is consumed. Most of the heat is produced in the reactor core, which is an assembly of alloy pins containing uranium that is partially enriched in U-235. Surrounding the core is a breeder blanket containing uranium that is depleted in U-235. Nearly 75 per cent of the new fuel (plutonium) is produced here. Heat is removed from the reactor core and blanket by circulating sodium, transferred to a sodium-potassium alloy (NaK) system in an intermediate heat exchanger, and is then transferred to water in a once-through type of steam generator.

The Fast Breeder

The fast breeder planned by the Detroit Edison group will have a heat output of 300,000 kw and the station will have an electrical output of 100,000 kw. The critical mass will consist of 450 kg (9900 lb) of U-235. The amount of this U-235 consumed each year will be 91.7 kg. The consumption of these 91.7 kg of U-235, however, will produce 109 kg of plutonium each year. Thus, the reactor has a breeding ratio of 1.2. Another attractive aspect of the sodium-cooled fast breeder is the higher steam temperature it can produce. In the case of the proposed Detroit Edison plant the steam pressure will be 600 psi and the temperature 750 F. The fast breeder is a bold step forward and some scientists are skeptical regarding its early completion. It is scheduled for completion late in 1959. In many ways it is a tricky monster. Indeed, it comes about as close to an atomic bomb as anything in the nuclear field. The first step toward this plant is the construction of a test reactor to be installed in the Delray Plant of the Detroit Edison Co. This test facility, a 4 million dollar project, is being constructed by United Engineers and Constructors. See Fig. 5.

Shippingport

The Shippingport reactor, then, is of the regenerative or stretcher-outer type. The seed (primary fuel) assemblies contain a total of 52 kg (1144 lb) of enriched uranium. This constitutes the central core of the reactor. Around this is a blanket containing 12 tons of uranium in the form of uranium oxide. During operation the neutron flux converts part of this UO_2 into plutonium, which being fissionable, also produces heat. At the start of the reactor life approximately 60 per cent of the total power will be produced in the blanket assemblies and 40 per cent in the seed assemblies.

Of far greater interest from a development standpoint is the Dresden Station planned by Commonwealth Edison Co. and the associated companies in the Nuclear Power Group. This plant will use a dual cycle boiling water reactor based on the experimental work carried on by Argonne National Laboratory under the direction of Dr. Walter Zinn over the past four years.

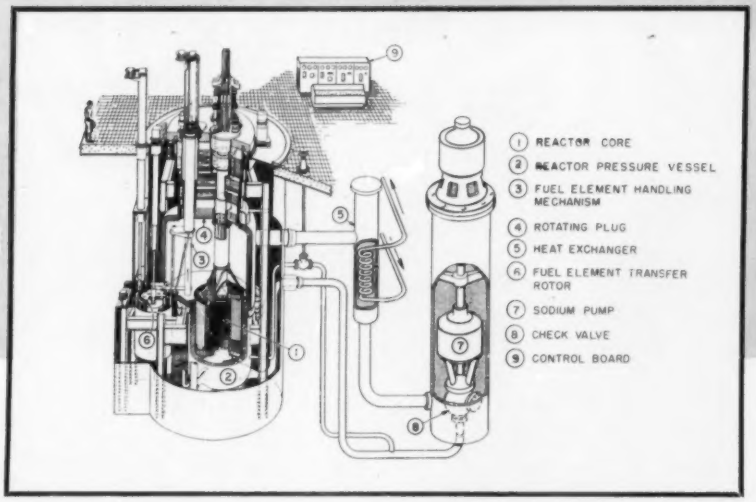


Fig. 5. Diagram of the full size fast breeder reactor test facility of the Detroit Edison Co. group to be installed in the Delray Station of the Detroit Edison Co. The sodium pump (7) is a 1000-hp motor driven pump capable of delivering 11,800 gal of sodium per min.

The boiling water reactor simplifies matters by generating steam within the reactor itself. The steam is then used directly in the turbine, eliminating the need for intermediate heat exchanges. Another advantage of this type of reactor is that it is self regulating and thus inherently safe. This characteristic of its operation was proved by the brilliant experiments of Dr. Zinn at the AEC National Testing Site. These experiments were made with the first boiling water reactor (Borax-1) built especially to test the transient performance of this type of reactor. At the conclusion of these tests, all of which indicated that the reactor was completely self regulating, the reactor was subjected to a final (destructive) test in which the power rose to more than ten million kilowatts in a tenth of a second.

The success of Dr. Zinn's experiments with Borax-1 (the one that was tested to destruction), Borax-2, and Borax-3, led to the choice of this type of reactor for the 180,000-kw Dresden Station of the Commonwealth Edison Co. to be built some 40 miles south of Chicago. This will be a dual cycle plant. In addition to the main steam supply from the reactor at 600 psi, the throttle pressure, steam will also be supplied to an intermediate stage of the turbine at 350 psi from a flash tank. The latter receives hot water directly from the reactor. In the flash tank the pressure is reduced, causing a fraction of the water to be converted into steam, while the remainder is cooled as a consequence of the evaporation. This cool water is then pumped back to the reactor to provide the sub-cooling required to maintain a high reactor output. According to Willis Gale, Chairman of the Board of the Commonwealth Edison Co. this plant will generate electricity at a cost on a par with that of the company's large coal-fired plants. This estimate is valid only, however, if a $15,000,000 item for research and development expense involved in the design of the *first* plant is excluded. At present, said Mr. Gale, the cost of power from the Edison's large coal-fired plants is 7½ mills per kilowatt-hour.

Among the applications to build nuclear power plants last year one of the most significant was the one made by the Rural Cooperative Power Association for the construction of a plant near Elk River, Minn. The reason the Elk River application is important is in the fact that this is the first time so small a central station plant has been proposed. The project involves only a 22,000-kw plant. The value of so small a plant is important to the whole future of industrial development in the atomic age. Indeed, the Atomic Energy Commission recently has offered new incentives to spur interest in such small plants.

Homogeneous and L-M Reactors

Curiously, one of the most promising and at the same time among the simplest types of reactors has not received much commercial attention so far. This is the aqueous homogeneous power breeder using a solution of uranyl sulphate in heavy water as the seed, and a solution of thorium in heavy water in the breeder blanket. The Foster Wheeler Corp. has offered a 100,000-kw plant using this type of reactor to the industry at an estimated cost to the owner of $21,000,000 — 210 per kw. Like the boiling water reactor the aqueous homogeneous reactor is self-controlling to the extent that, as demand on the steam generator increases the reactor responds by releasing the heat required. Specifically, this is accomplished through the expansion of the fuel which tends to decrease the amount of uranium in the core. The uranyl sulphate solution and the thorium solution pass through two separate heat exchangers in which the steam for the turbine is generated. Some 17 per cent of the total heat release comes from the blanket circuit. The remaining U-233 formed in the thorium solution is recovered by chemical processing.

Another intriguing type of reactor that has been neglected from a commercial standpoint — at least no utility group has come forward with a plan for using it — is the liquid metal fuel reactor developed by Brookhaven National Laboratory. For some time a study group of 50 scientists and engineers headed by Babcock and Wilcox Co. has had the LMF reactor under consideration. A recent report of this study group indicates its theoretical flexibility. A liquid metal fuel reactor this report states could be built to operate as a regenerative reactor producing about 80 per cent as much new fuel as it consumes. Such a reactor would use a liquid metal alloy of uranium and bismuth both as fuel and heat exchange medium and could involve continuous chemical processing. The nuclear characteristics are such that it could operate over a wide range of power outputs without external adjustments by the operator. Steam produced in the LFMR would be of temperature and pressure high enough for turbines of the most modern design. The B & W atomic research group estimate that a 226,000-kw nuclear power plant could be built to produce power at 7.1 mills per kwh.

It should be evident even from this brief and sketchy résumé of last years nuclear power developments that despite some opinion to the contrary, nuclear power is definitely under way. Admittedly, many technical problems remain to be solved, particularly the waste disposal problem, but the high energy concentration of nuclear fuel and the enormous potential reserves make the development of nuclear power inevitable. Uranium-235 costs $15 to $30 per gram and on a fuel cost basis this means 2 to 4 mills per kwh power. A pound of refined natural uranium costs around $20.00. Its equivalent — 1500 tons of coal — costs something like $10,000. Therefore, if we consider raw fuel costs alone, uranium enjoys a several hundredfold advantage over coal or any other fossil fuels.

Many Steam Plant Trends Take Firmer Shape in 1955

Two more supercritical pressure plants announced, making total of 3 now under way; package water tube boilers; fly ash refiring; vibrating grate stokers; fluid coke a new boiler fuel; heat pump in sewage and waste disposal; cooling tower test codes; high-temperature water

By CHESTER R. EARLE
Executive Editor,
POWER ENGINEERING

ANNOUNCED developments in the power engineering field during a given year are usually the result of a relatively long period of development before they come to fruition. This has been the case with the developments of 1955. Those arousing greatest interest during the year are the announcement of actual construction of atomic energy plants and of design and construction progress on equipment for supercritical pressure plants. Latest word on the atomic plant development is given in the preceding pages. Highlights of the supercritical steam development will be given here. But while these two items have attracted most attention in 1955, steady progress and a number of less spectacular but no less important trends in conventional plants have taken firmer shape during the year.

Power plant steam conditions in conventional types of units rose over the years toward the 2500-psi 1100 F region. The heat rate under these conditions begins to level off at just above 9000 Btu per kwh. Knowledge of the metallurgy for those conditions was accumulated, so engineers began to ask if another big gain in economy could be attained by going to pressures above the critical pressure of 3206 psi. The work of Potter, Solberg and Hawkins in 1932 with an experimental unit operating at 1500 to 3500 psi and 830 F was well known.

Supercritical Pressure Plants: — Accordingly, power plant designers and equipment manufacturers began studying and testing experimental equipment and pilot installations. As a result, it was announced in July 1953 that a 125,000-kw unit to operate at 4500 psi, 1150 F with reheat at 1225 psi, 800 F and again at 185 psi, 630 F would be installed at the Philo plant of Ohio Power Company, a member of the American Gas & Electric System. Full details of the entire design of this steam-electric generating unit are given in ASME paper No. 55-A-137 by S. N. Fiala.

This unit, to be called Philo Unit 6, will be fitted into a space only slightly larger than that made available by removal of Unit 2, a 40,000-kw reheat machine that has been installed at Philo since 1923. Figure 1 shows the flow diagram of the Unit No. 6 turbine unit, adapted from ASME paper No. 55-A-159 by Elston and Sheppard, which gives full details of the turbine design. Figure 4 shows a perspective of the 4500-psi cyclone-fired boiler, adapted from Fiala's paper.

The turbine will be a single-shaft, 3600-rpm machine, with a h-p turbine, exhausting at about 1250 psig 800 F through a reheater that raises it to 1050 F, to an intermediate section, which in turn exhausts at about 207 psig 660 F through a second reheater that raises it to 1000 F, to a double flow low-pressure turbine section and thence to the condenser. Steam cooling of interior parts will keep wall thicknesses of austenitic steel parts as small as possible.

Second supercritical unit to be announced was one for the Eddystone Station of Philadelphia Electric Co. This is to be a 325,000-kw unit to operate with steam conditions of 5000 psig, 1200 F with double reheat to 1050 F. The unit will be a cross-compound unit, consisting of a super-pressure unit operating at 3600-rpm, exhausting to a very-high-pressure-high-pressure element on the same shaft, thence to intermediate and low-pressure-elements on the 1800-rpm shaft. Details were given by C. C. Frank before Southeastern Electric Exchange, as reported in *Combustion*.

Steam generating unit for this Philadelphia unit will be based on the monotube type developed in Europe, but its details have not yet been disclosed at this writing.

One important factor in developing equipment for supercritical operations is the possibility of using modern water purification processes that reduce foreign matter to as low as 0.5 ppm in the water. However, we do not yet know all the reactions that may take place in a supercritical fluid. This was discussed by Everett P. Partridge in an ASME paper entitled Water Problems in Power Generation at Supercritical Pressures or Through the Looking Glass. Dr. Partridge sums up the operation as the process of making steam that is not steam in a "boiler" that does no boiling. He discusses what we know about the solubility and reactions of silver, sodium and calcium compounds and iron oxides at high pressures and temperatures.

Boiler feed pump power in super-

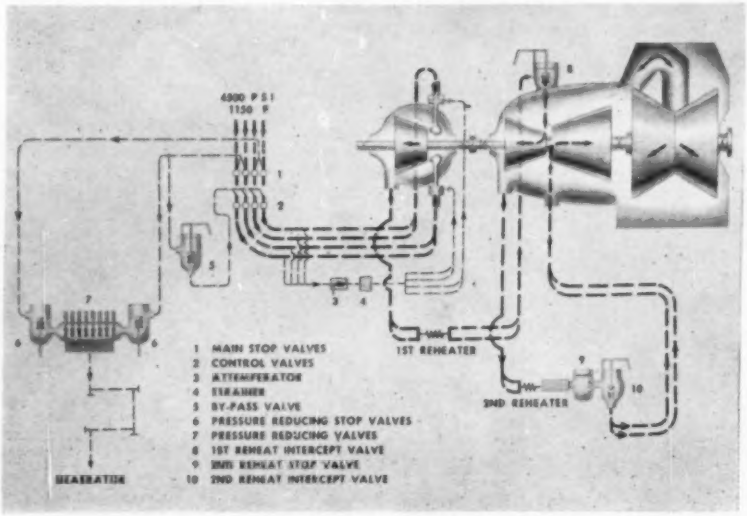


Fig. 1. Steam flow diagram for 125,000-kw, 4500-psi 1150-F tandem—compound steam turbine Unit No. 6 for Philo plant, replacing old Unit No. 2

Fig. 2. View showing 15 steam turbine generators, 20,000-kw each but capable of 25,000 kw, installed at Chalmette plant of Kasier Aluminum & Chemical Corp., Chalmette, Louisiana

critical plants is another problem. Consideration is being given to use of high-speed feed pumps driven through gears by motors and to use of high-speed direct-turbine-driven pumps.

Frank has also described a third supercritical unit just announced, to be installed by Cleveland Electric Illuminating Co. He notes this is a 215,000-kw unit, but a late CEI Co. statement refers to a 250,000-kw unit. It is to be tandem compound, operating at 3600 rpm, arranged as in Fig. 3. Initial steam conditions are 3500 psig, 1100 F and there is a single stage of reheat to 1050 between VHP and HP elements. The steam generating unit here also will be of the monotube design.

General Plant Design: — Conventional steam power plant development continues much as it has for the past two or three years. In the utility field many units of 100,000 to 200,000 kw capacity have been and will be installed; and, as noted last year, a couple of units of 300,000 kw and above are being planned. In most cases these are served by one steam generating unit, the majority fired by pulverized coal. Outdoor and semi-out-door plant designs are used in many cases, although indoor installation of new units still predominates.

In industrial power plants, demands for heating and process steam continue to demand modernization of many plants and expansion of others, resulting in many new boiler installations. These are usually for low-pressure operation (200 psi or less) because the proportion of industries buying all or part of their power continues to increase, and higher-pressure operation is used only where by-product power generation is economical.

Steam Generating Units: — Notable among boiler developments this year seems to be a trend to package type units for small installations requiring only steam. Use of the fire-tube package units in capacities up to about 10,000 lb of steam per hr is now well established. But now, many of the major manufacturers can supply small water tube package units for capacities up to about 25,000 to 30,000 lb per hr. A recently-developed water-tube package unit, capable of burning coal, oil or gas, is described elsewhere in this issue.

Particularly interesting development of the year was the experience recorded in quick starting of industrial plant boilers (PoE, April 1955). Boilers of 150,000 per hr capacity were started from very low temperatures to full operation in as little as 90 min.

Boiler Feedwater Treatment: — Trend of recent years has been toward more wide-spread treatment of boiler feedwater by deionizing units. Constant improvements are being made in this technique. There is increasing interest in automatic operation of these units (PoE, November 1955).

Use of hydrazine as an oxygen scavenger in boiler water is still in the early stages of development, and there has been considerable interest in it during the past year or so. Commonly-used oxygen scavenger is sodium sulfite. Recently Hess and Wofford reported successful use of hydrazine and sulfite as a team in a large central-station 625,000-lb-per-hr, 1500-psi, 1000 F/1000 F reheat unit. (PoE, September 1955.) Comments on experience with hydrazine have also been given by two other users of it. (PoE, November 1955.)

Firing Equipment and Fly Ash: — Present-day demand for air pollution abatement also makes it necessary to obtain minimum stack emission and boiler deposits along with best combustion.

By treating fly ash as an advantage because of its carbon content, instead of as a nuisance, and considering it as fly carbon rather than ash, one large industrial company has developed a gravity re-injection system for spreader stokers, as reported by C. E. Morrow. (PoE August 1955.) Using this system, all the company's boiler units now operate with total carbon loss of less than 0.2 per cent in boiler efficiency heat balance, and employ less than 20 per cent excess air. The carbon loss up the stack is 0.2 per cent of the carbon fed to the furnace. No difficulty is experienced with slagging or clinkering of any sort, and there is no fouling of heating surfaces. The boilers are not equipped with soot blowers and in 12 years, it is reported, it has not been necessary to clean the gas side of any boiler.

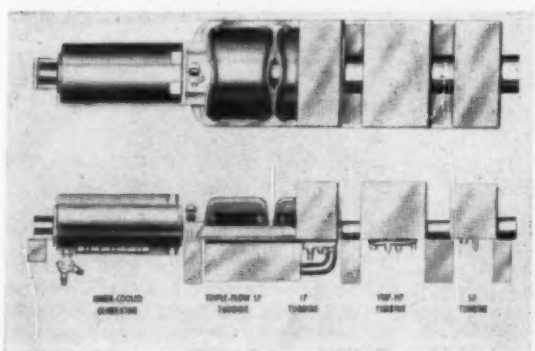


Fig. 3. Arrangement of 215,000-kw reheat tandem—compound 3500-psig, 1050-F steam turbine generator unit

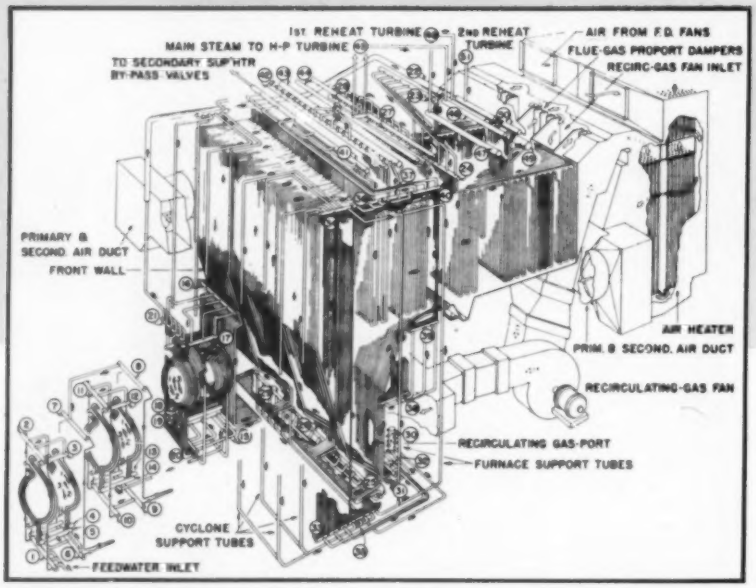


Fig. 4. Perspective view of steam generator for Unit No. 6 at Philo plant. Fired by cyclone furnaces in front of pendant superheaters and reheaters. Rated at 675,000 lb per hr, 4500 psi, 1150 F with two reheater sections

Another important development in fly ash refiring to dispose of fly ash and reduce disposal cost was reported by F. G. Feeley, Jr. in ASME Paper No. 55-A-182. He reported construction and operation of a boiler of the type shown in Fig. 7. This is a slagging bottom unit, with a hearth of refractory construction but completely separate from the structural and pressure parts of the boiler.

The boiler is fired by downwardly-inclined adjustable burners, 3 in the front wall, 3 in the rear wall and staggered. A slag-top opening is at the side of the hearth. Object is to release the heat at the bottom of the furnace, maintain the slag molten on the hearth, refire the collected fly ash at the furnace bottom, allow the burned-out fly ash to be trapped in the slag and tapped off with it. The slag is readily disposable and sometimes salable. Dust is collected from various boiler hoppers, is picked up by reinjection feeds and refired by nozzle located between and below the rear coal burners.

In short, this boiler disposes of its own fly ash. Similar smaller boiler in another plant consumes, in addition, fly ash from an adjacent dry-bottom boiler; and, in the unit of Fig. 7, arrangements are being made to fire dust from adjacent units.

Furthermore, an unexpected result is that no fouling or slagging of heating surfaces has occurred to date in this boiler, no soot or slag blowers are installed, no manual cleaning has been required.

Finally, the boiler, rated at 289,000 lb per hr, but operated at about 310,000 lb per hr, has operated at 88.6 per cent efficiency at design steam flow. In addition to pulverized coal, the unit has successfully burned other fuels, including natural gas, also fluid coke, a new fuel referred to in third column on this page.

In the stoker field, a new form of spreader stoker known as the vibrating and another called oscillating grate stoker was announced during the year by several manufacturers, although they had been under test for some time.

One vibrating grate stoker installation has grates that are vibrated forward and backward $\frac{3}{64}$ in. about 550 times per minute, for a few seconds, and then are quiet for a few minutes. Object of this is to keep the fuel bed intact, with no holes, but at the same time porous to keep combustion air pressure at a minimum. Although tests with various fuels have not yet been run, fly ash is reported to be low. Vibrating grate stoker of another make is installed on a package steam generator as described in the article Stop Worrying About Fuel elsewhere in this issue.

Fuels: — For some time, tests have been conducted on a method of aerating crushed coal in order to make it flow out of a bunker or container rapidly, almost like a liquid, and empty the bunker completely. This work (PoE, November 1955) was initiated primarily for the coal-burning gas turbine of Locomotive Development Committee, which is investigating possibilities of carrying prepared coal fuel on the locomotive instead of conditioning it on the locomotive. In ASME Paper No. 55-A-118, Charles H. Marks, with Yellott and Broadley, reports the details. They showed how aeration permits a coal storage tank to be filled to the top, without the usual cone; the surface of the coal rises horizontally like a liquid. The coal can be virtually all discharged, only a small portion — 5 or 10 per cent — remaining in the tank. Results of this work indicate that the aeration method holds promise for application to stationary coal-burning power plants as well as to the locomotive.

Fluid coke has recently been announced as a new power plant fuel and has aroused much interest. Developed by Esso Research and Engineering Co., it is a by-product of a new refining process. In this process, the fluid coke is produced in large quantities; studies and pilot plant tests indicated it could be used as boiler fuel. Tests were run at Battelle Memorial Institute and also at Allis-Chalmers and full-scale combustion tests of the material have been run on boilers at Essex Station of Public Service Electric & Gas Co. The fluid coke has also been burned in the boiler of Fig. 7 and tests are also being made at a plant of Pacific Gas & Electric Co. Three boilers are being installed in Delaware, the basic fuel being fluid coke. Kaiser Engineers also report successful burning of fluid coke in a cement kiln.

Another petroleum refining process produces a material known as delayed coke. A new station of VEPCO (PoE, October 1955) is being designed to burn this delayed coke simultaneously with refinery gas and coal. A large refinery is being built adjacent to the power plant to supply the delayed coke and refinery gas.

The coal industry as a whole is feeling more optimistic this year than it has for some time. In 1955, it is

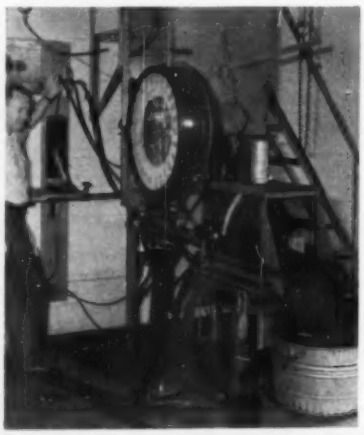


Fig. 5. Test equipment used in developing method of aerating fine coal so it flows like liquid, with horizontal surface, fills bin, empties 90 per cent

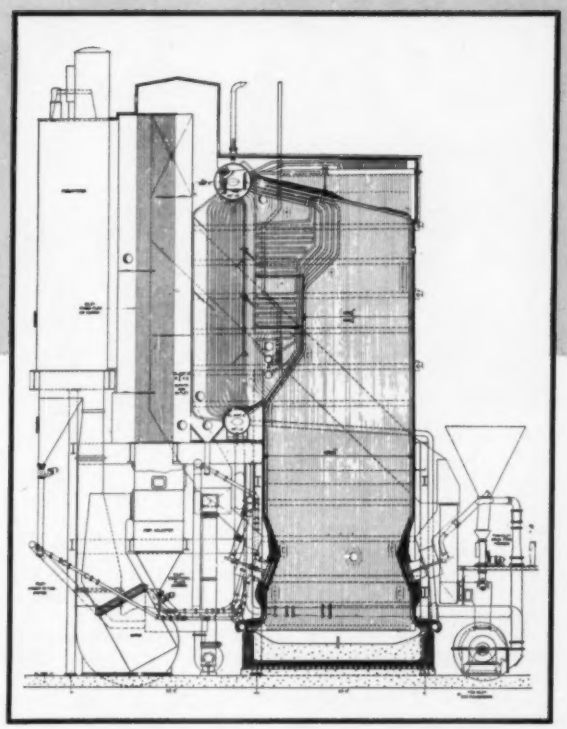


Fig. 7. Cross-section of a 289,000 lb-per-hr boiler with slagging bottom, designed for refiring fly ash so that boiler disposes of its own fly ash, also ash from adjacent boilers. Unit has experienced no slagging or fouling

estimated that production will reach about 470,000,000 tons, a 20 per cent increase over 1954. The demand has turned up; utilities are using more coal as they build new power plants to meet the rising electric demand; the steel industry and the chemical industry are using more coal and the overseas market has picked up. More important, coal men feel that as the nation's production increases, total fuel demands for oil, gas, coal, atomic fuels will rise to the point where we will need a billion tons of coal a year by 1960, in addition to everything else.

This may be wishful thinking, but it looks as though coal is starting a comeback. Certainly it remains the basic fuel of the power utility industry and of a great many manufacturing industries as well.

H-P, H-T Water Systems: — Typical of a number of the h-p, h-t water systems for building heating now being installed in this country, is one at the Naval Supply Depot, Great Lakes, Ill. (PoE, December 1955.) Here two multi-fuel fired, forced-circulation water-tube generators, each rated at 20,700,000 Btu per hr output, supply water at 300 psig and 420 F to a system serving many buildings and covering a large area.

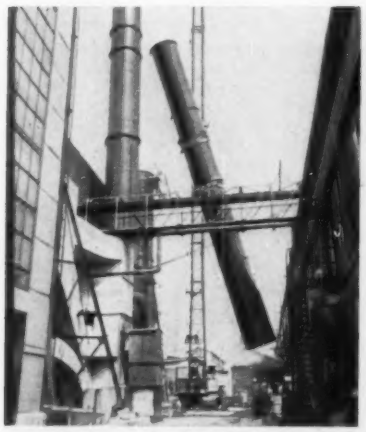


Fig. 6. Second glass-coated stack being erected at A. O. Smith Co. plant. New process lines stack with glass to resist corrosion by flue gases below dew point

So far, h-t water systems have been used in this country principally by the military services, at Air, Marine and Naval bases. Interest is rising in this heating method, however, and it is expected that more industrial and commercial applications of the system will be made in the near future.

One advantage of h-t water system is the heat-carrying capacity for long distances with minimum heat loss. Pipe sizes are smaller as compared to steam piping and makeup water is a negligible item. On the other hand, if steam is desired at any point, converters must be used. The water system must be properly vented and designed for draining and filling for maintenance. On the whole, the advantages predominate and the existing installations of h-t water report good economy, simple and satisfactory operation, low maintenance and general good performance.

Cooling Towers: — During the past few years, more and more cooling towers have been installed not only for air conditioning installations but also by industrial plants for process and power plant cooling water and by power utilities for circulating water cooling. Fact is, as often pointed out, by proper use of cooling towers, it is possible to locate a power plant where desired even though the water supply is scanty or must be drawn from a distance.

Nevertheless, there has not been too much reliable information available on how to test tower performance, nor how to design towers structurally. This lack has now been remedied by the Cooling Tower Institute, which has conducted a 5-year research program involving tests on many existing towers. Results of this work, also bulletins giving complete details for testing by manufacturers and users, were announced during the year. (PoE September 1955.)

Industrial Waste and Sewage Treatment: — Problems in this field are becoming an increasing concern of power engineers for several reasons. First, because of the demand for air and water pollution abatement, industry must install its own sewage and waste disposal plants, as many are already doing. And more must come; it is estimated that some $4,500,000,000 needs to be spent to provide adequate industrial waste treatment facilities and the same amount for municipal sewage.

Second, the power engineer is involved in the problem because of the effect of all this on the country's electrical facilities and power needs. Stratton estimates (PoE, September 1955) that by 1960 we can expect an increase of 3,840,000 kwh per 24 hr for sewage treatment and pumping and 740,000 kwh per 24 hr for industrial waste.

Third, the power engineer is involved because the problems involve many of the pumping, measuring, piping and handling techniques with which he is already familiar. For example, many municipal plants generate power from sewage treatment by-product gases, burned in internal combustion engines. Moreover, heat must be generated in some way in many plants for the treatment processes and this is often done with conventional boiler plants.

But a new idea is being tried —

Fig. 8. Mechanical rotary vacuum pumps used for condenser air removal eliminate auxiliary steam need at PSE & G plants

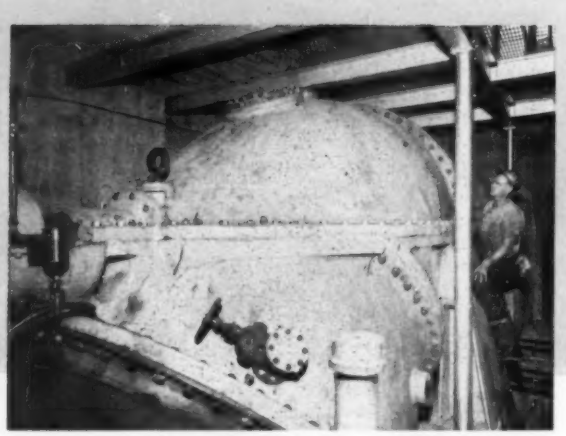


Fig. 9. One of six 116-in. axial flow pumps, gear driven by diesel engines, pump out flood waters of Florida Everglades

use of the heat pump as a source of heat in a sewage treatment plant. As explained by Minish (PoE May 1955), this has been done successfully in a small hospital sewage plant. A much larger installation using the heat pump in a new municipal sewage treatment plant is now being designed and constructed and will be reported on later.

Example of a self-sufficient sewage treatment plant is the Joint Disposal plant of Los Angeles County Sanitation District. (PoE March 1955.)

Here the plant's power house contains engines operating on sludge gas plus standby propane, driving mixed-flow pumps and electric generators, and all water is drawn from a well on the plant grounds. No power lines, gas or water mains enter the plant from outside.

By a new method, it is possible that organic wastes, from spent pulp liquors to sewage sludge and garbage, can be burned submerged in water, at the same time generating 2200-psi steam. If this is accomplished (PoE, December 1955), stream pollution can be eliminated by certain types of plants that also tend to benefit economically.

In one proposed paper mill installation, for example, treatment of waste pulp liquors by this method will supply 220,000 lb per hr of 2200-psi steam, representing an annual fuel bill of over $1,000,000.

Materials: — Power engineers must use many different kinds of materials in the operation and maintenance of their plants. In many cases, these must be incorporated in power equipment by its manufacturers; in others, the power engineer may install them himself. In either case, he should have considerable knowledge of them. Here are a few of the materials in which he has been interested recently:

Double-density concrete has been developed (PoE, October 1955) that is strong, acid-resistant, easily mixed and poured.

Method of chromium-plating Diesel engine cylinders (PoE, December 1955) with an electro-deposited material that has controlled porosity, is dimensionally accurate and well adapted for lubrication. It is also applicable to compressor cylinders, steam cylinders and other surfaces subject to hard wear.

Insulation you paint or spray on in a thin coat, which swells up to 20 times the coating thickness and forms a foamy, semi-rigid insulation (PoE March, October, 1955).

Method of hot-spraying of vinyl paint (PoE, September 1955) that overcomes difficulties of applying this effective corrosion-resistant coating.

Tough glass coatings that promise long life and economy for steel stacks (PoE, August 1955).

Irradiated polyethylene for hot-spot electrical insulation (PoE, June, 1955).

Armored Cable — it helps cut costs and improves appearance (PoE April, May 1955). Glass bubbles make tough, versatile insulating wall (PoE, April 1955).

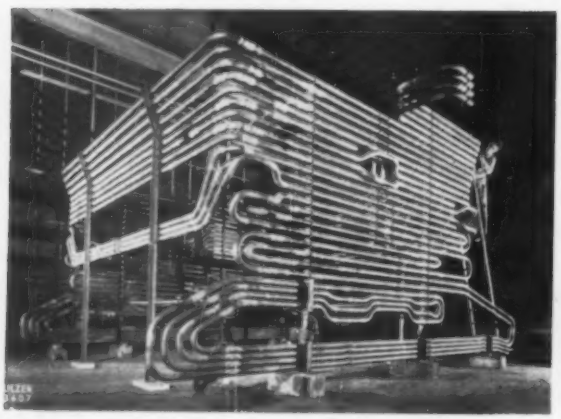


Fig. 10. Combustion chamber European monotube steam generator; American supercritical units based on monotube principle

Fig. 11. Two h-p, h-t water generators of forced circulation type, fired by coal, oil or gas for new system at Great Lakes

Hydro, Diesels, Gas Turbines in 1955

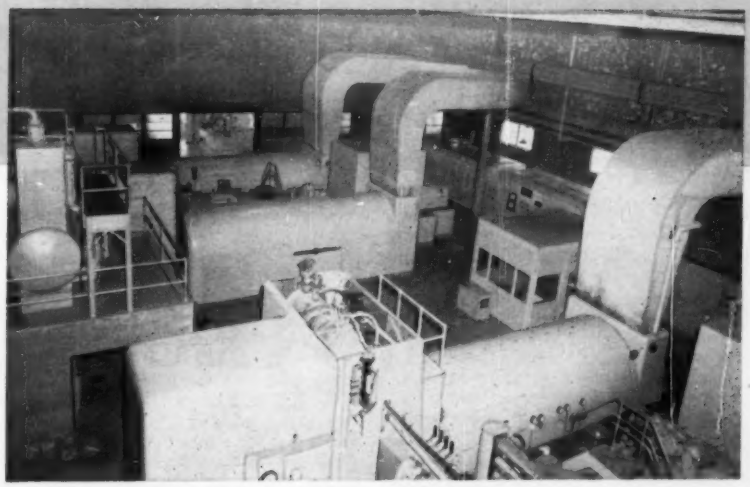


Fig. 1. Two 5000-kw oil-burning regenerative-cycle gas turbines at the E. M. Graham Station, Bangor, Maine. Work is continuing here on treatment of residual fuel oil as noted in text

HYDROELECTRIC capacity installed during the year totalled about 1,000,000 kw but practically all of this had been previously planned and a very small number of new hydro units was manufactured. Total installed hydro capacity of about 28,000,000 kw supplied only a little over 20 per cent of the total power generated.

However, important developments such as that on the International Section of the St. Lawrence River are going ahead. Propeller type units of 55,000-kw capacity each have been ordered for the Canadian half of the development and an equal number for the United States side. Total capacity will be 1,700,000 kw.

Pumped Storage: — For the Sir Adam Beck plant of the Niagara Falls project, six pump turbines are to be installed. They are designed to be of the propeller type, rated at 45,000 hp as turbines and 55,000 hp as pumps. Installation work is going ahead on the largest reversible pump-turbine unit in this country, the unit at Hiwassee Dam of TVA, rated at 59,500 kw when generating.

Gas Turbines: — Test work on the coal-burning gas turbine is expected to reach completion in 1956, according to Col. R. B. White, chairman of the Locomotive Development Committee. It is anticipated that the first coal-burning gas turbine locomotive will be under construction in 1957.

Effective January 1, 1956, Peter R. Broadley will become director of research of LDC, succeeding John I. Yellott, who is joining Stanford Research Institute.

Another experimental coal-burning gas turbine has been tested in Canada, as reported by Mordell and Foster-Pegg in ASME Paper No. 55-A-158. This unit is of the exhaust-heated type, using a cyclone-fired combustion chamber, supplying hot gas to a tubular heat exchanger that heats air, which passes through and drives a 540-hp, 13,500-rpm gas turbine and centrifugal air compressor.

First municipal gas turbine plant, a 1250-kw simple, open cycle unit, has been installed by the city of Larned, Kansas.

Interest is rising in the idea of combining the gas turbine and steam turbine cycles. This has been discussed often from the beginning of gas turbine development and at least one such combination is in commercial operation.

In ASME Paper No. 55-A-184, Mayers, Matiuk and Baron describe two highly efficient coal-fired combination gas and steam turbine power plant cycles and the effects of a number of cycle variables on plant efficiencies. They would have heat rates below 9000 Btu per kwh. One is a supercharged boiler cycle, the other an exhaust-heated cycle.

Problems of burning residual oils in the gas turbine and avoiding the deposits caused by vanadium and sodium compounds in the oil, at temperatures above about 1100 F, seem on the way to solution. On the Rutland, Vt. gas turbines, centrifuging, washing, desalting and treatment of the oil with magnesium sulfate has promised excellent results. Similar work is being carried on with several residual oils on two oil-burning gas turbines at E. M. Graham Station at Bangor, Maine, Fig. 1, but final results have not yet been reported.

Finally, Union Pacific Railroad has ordered fifteen 8500-hp gas turbine locomotives and expressed intent to order two additional blocks of fifteen each. These units will burn treated Bunker C fuel oil. They are in addition to the 25 gas turbine locomotives already operated by Union Pacific.

Also during 1955, a mobile gas turbine unit (PoE, August 1955) of 5500 kw was put on rails for the U. S. Navy. It will be especially useful for disaster power or load relief.

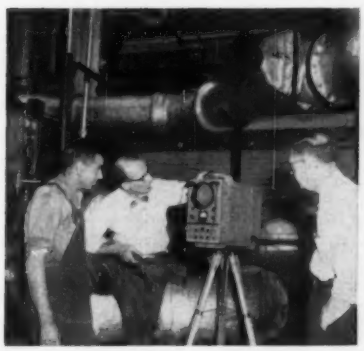


Fig. 2. This engine analyzer makes diagrams that will locate hidden engine faults in a matter of minutes

Fig. 3. View in Engine Room No. 1 at Kaiser's Chalmette plant, showing some of the 80 vertical gas engines

Fast Growing Load Creates Difficult

The tremendous increase in the use of electricity by both residential and industrial customers is taxing the carrying capacity of both the transmission lines and the distribution systems of the country. Distribution systems installed 20 years ago are no longer adequate and this means either their replacement or improvement. Last year our installed capacity reached a value of 125 million kw. By 1970, the installed capacity will be 320 million kw

THE COMBINATION of private and government-owned power plants in the United States during 1955 produced a total of 620 billion kilowatt-hours of electrical energy. This includes some 76 billion kilowatt-hours generated in industrial power plants. It compares with a total of 545 billion kilowatt-hours generated in 1954.

This better than 13 per cent increase in our electric power production in a single year is primarily the result of two factors in our economic growth. The first of these concerns population, the second, productivity.

Our present rate of population growth is in the neighborhood of three million a year and last year the population of the United States reached a total of 165 million. By 1970, only 15 years from now, it is estimated we will have a total of 204 million, 22 per cent more than we have today.

This increase in population alone would account for a substantial increase in our use of electricity but over and above the effect of population growth is the influence of industrial production. This affects our use of electricity in the domestic as well as the industrial and commercial areas. Increased industrial production means more buying power — more washers, dish washers, dryers, etc., and this, in turn spells more load and more development.

Through the years the average residential use of electricity has been steadily increasing. In 1955 the average residential customer in this country used 2750 kwh. This compares with an annual use of only 1830 kwh in 1950. By 1970 the average residential customer will be using around 7700 kwh — three times as much as he is using today. At the same time the amount of electrical energy used in industry wil rise from the 320 billion kwh used last year (1955) to 625 billion kwh in 1970 — an increase of 95 per cent.

This great increase in the use of electrical energy together with the steady development in technology accounts for the tremendous progress reflected in all phases of the electrical industry. To supply this constantly increasing electrical load we need more power facilities — more and larger generating stations, longer, higher capacity transmission and switching facilities, and tremendously expanded distribution systems.

A significant aspect of the power industry today is the preponderance in use of central station power in industry. Today, industry generates only 24 per cent of the power it uses. By 1970, this proportion will be down to 18 per cent.

At a time when most costs are still rising it is significant that the construction costs of large central stations are somewhat below what they were a few years ago. A survey of the costs of a representative group of central stations built in 1955 showed an average cost of $130 per kilowatt in the range of from $100 to $170.

In 1952 the average cost was $130 to $135, while in 1950, it was from $145 to $150. These lower construction costs to a high degree reflect the skill and resourcefulness of our power plant designers. One contributing factor in this cost reduction is the increased reliance on larger generating units, centralized control and the use of outdoor type of equipment.

An analysis of central station operation shows that the heat rate, that is, the thermal efficiency, improves with size. The heat rates vary from a high of around 12,500 Btu per kwh for stations in the 20,000 kw class to a low average of less than 10,500 Btu per kwh for stations of 300,000-kw capacity. At the same time it can be shown that station costs rise as the heat rate decreases.

This, of course, is due to the higher cost of the high pressure and temperature equipment and more complicated steam cycles required to attain the higher efficiencies. In general it seems to be economical to increase the station cost one dollar per kilowatt above normal cost for each 74 Btu per kwh improvement in heat rate.

Most of the large plants today operate at steam temperatures of 1000 F or better and at least half use pressures above 1400 psi. Average production costs in the large utility stations are 3.1 mills per kwh. The largest factor in this power cost is fuel which constitutes about 38 per cent of the total. This figure does not include fixed charges but it does include maintenance expense. The latter has become lower and last year approximately 65 per cent of the stations surveyed showed maintenance expenses of 0.2 mills per kwh or less. The total cost of power at the bus bars which includes investment, taxes, amortization, etc., average from 6 to 7 mills per kwh. This figure remained unchanged, being about the same as it was in 1952.

The 3.1 mill per kwh average production cost is of interest in relation to the use of nuclear energy. If, as pointed out above, 83 per cent of this constitutes fuel cost, this gives 0.83 x 3.1 or 2.57 mills per kwh, considering fuel cost alone. With uranium-235 selling for from $15 to $30 per gram we obtain an equivalent power cost of from 2 to 4 mills per kwh. On this

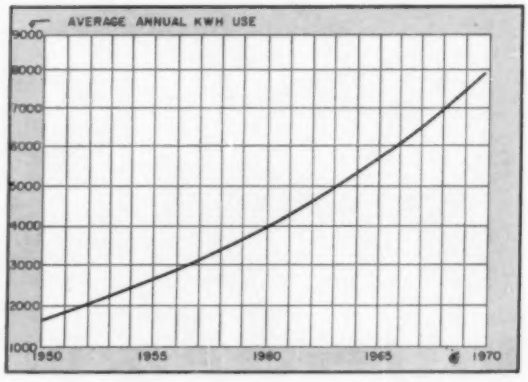


Fig. 1. This curve shows the way in which the amount of electricity used by residential customers is increasing. Last year the average customer used 2750 kw. By 1970—only 15 years from now—the average customer will then be using 7700 kw

Problems for Electrical Industry

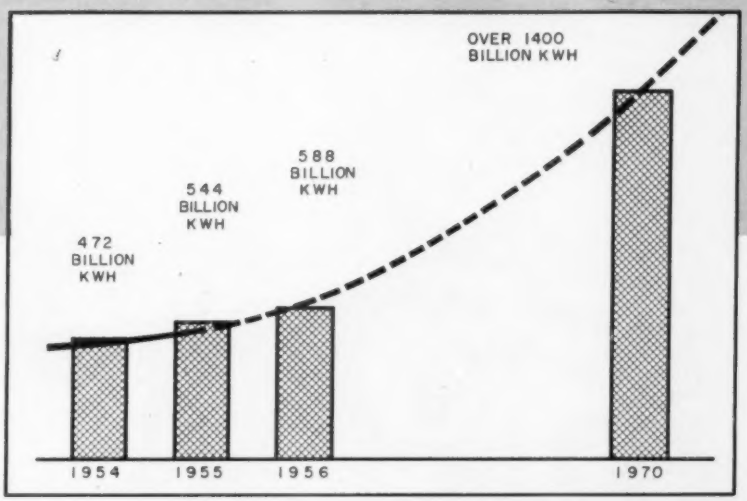


Fig. 2. In 1970 the total electrical energy used in the United States will be around 1400 billion kwh, almost three times the amount used last year

basis it is obvious that the lower uranium cost is easily capable of competing with conventional fuels.

During the year 12.8 million kilowatts of new electric generating capacity was added to the nation's power supply, bringing the total to 117 million kilowatts. This does not include the generating capacity installed in industrial power plants which is around 15 million kilowatts.

In 1956 the amount of new generating capacity added will not be as large but it will still come to some 8 million kilowatts, making a total for the nation of 125 million kilowatts. By 1970, however, we will be adding new capacity at the rate of around 18 million kilowatts a year, and at that time the nation's installed generating capacity will reach 320 million kilowatts.

The first nuclear power station in the United States will go on the line in 1957. This is the Shippingport Station of the Duquesne Light Co.

As indicated in another section of this review, a number of other nuclear power stations are in course of development and by 1960, when these are completed we will have somewhere around 500,000 kw of nuclear power capacity on the line. From that time on, it is expected that nuclear power development will be rapid. As experience with nuclear power plants accumulates and as construction and development costs are brought down, more and more nuclear power capacity will be added and in 1970, it is estimated, about 2½ million kilowatts of the 18 million kilowatts to be installed that year will be nuclear plants.

To supply the great demand for electrical energy, generating units are gradually increasing in size. Most of the very largest turbine-generators are of the cross compound type using a 3600 rpm high pressure machine as one shaft and another 1800 rpm machine for the low pressure element.

However, single-shaft units of 260,000 kw are under construction and larger ones are contemplated. The largest units now being installed are the two 260,000-kw turbine-generators for the Rouge plant of the Detroit Edison Company. These machines now going in are conventionally designed except the 3600 rpm generator of Unit No. 2 which will be of the inner-cooled design, both rotor and stator.

The first liquid-cooled generator was announced in 1954 but the system is rather slow in coming into use. It probably will be developed more rapidly after the first machines using this method of cooling have been in operation. A large machine of this type is being built for installation in the East Lake Station of The Cleveland Electric Illuminating Co. This is a 260,000-kw machine running at 3600 rpm. The stator conductors will be liquid cooled while the field winding will have direct hydrogen cooling with 30 psig hydrogen.

The cost of turbine-generators decreases with increase in capacity. At the present time generators in the 40 to 70 Mw range cost from 27 to 34 dollars per kilowatt, depending upon the steam pressure and whether or not reheat is used. In the 150 to 200-kw range, the costs are from around $11 per kw for a 150 Mw, 1250 psi 950 F unit to $23 per kw for a 200 Mw, 1800 psi, 1050 F unit.

Transmission and Distribution

The most serious problems involved in the steadily expanding electric power system of the nation lie not so much in the generating end but in the transmission and distribution systems which carry the power to the consumers.

Many distribution networks in the heavily populated and rapidly growing residential areas are already being overloaded resulting in serious cases of voltage drop. The great increase in electrical consumption in residential areas is making portions of almost every distribution system obsolete. Many homes are wired for a 14 kva demand when, today, "adequate" wiring calls for 24 kva. In the majority of cases the service drops to these homes are of No. 6 copper or equivalent and in some 13 per cent, No. 8 wire is used. Such conductors might have been adequate 20 years ago when they were installed but today, with the large scale use of electric ranges, dryers, dish washers, water heaters and a host of other appliances, they are obsolete.

Among the factors that influence distribution systems in recent years the so-called heat storms that have hit certain areas of the country have created considerable disturbance. When continued heat waves hit these areas the system demands soar to unprecedented heights because of the widespread use of air conditioning equipment. Many utilities have had to take special measures to meet these sudden demands for power. But money spent to meet emergencies is never as productive as the same amount spent on well planned system improvement.

These problems, therefore, are being given serious attention but they are difficult to solve because of the widespread nature of the systems involved. It obviously will be an expensive procedure to replace a large part of the existing distribution systems with larger conductors. To raise the voltage, on the other hand also imposes serious questions. Is the rapid trend to 12.5 and 13.2 kv in fast growing areas proof that the existing 2.3 and 4-kv systems should be ripped out? Is the destruction of lines and serious outage caused by sleet and hurricanes proof of poor planning and design? Certainly design practice that plans new distribution facilities exactly as they were designed 20 years ago should be branded obsolete but existing systems cannot properly

Fig. 3 and 4. Two significant developments from RCA Laboratories. At left, view of apparatus for production of synthetic music and sounds by electronic means. Right—view of David Samoff demonstrating newly developed light amplifier

be condemned until all possible means have been taken to adapt them to meet present and future needs.

Transmission Lines

Transmission systems are also suffering from heavy loads resulting from the great demand for electricity. Present conditions make it necessary to locate generating stations 50 or more miles from the load centers.

Many companies are endeavoring to meet the situation by reconductoring existing transmission lines originally built with small conductors. This is an effective means of increasing the loading capabilities of existing circuits. Such reconductoring, however, must be carried out in advance of heavy loads approaching the conductor's thermal limits. If the delay is too long, the circuits may be so heavily loaded that they cannot be spared for reconductoring operations.

Another method of increasing the carrying capacity of existing transmission lines is by the use of duo-conductors. Duo-conductors, or bundling of conductors as the practice is more generally known in this country has been used widely in Europe but it has been considered by only a few utilities on this side of the Atlantic.

The practice involves the use of two or more conductors per phase as an alternative to reconductoring the line with larger copper. Duo-conductors have the added advantage of reducing the reactance per phase, thus reducing the line voltage regulation. It eliminates the necessity of removing the existing conductors, providing the conductor can be prestressed.

As already mentioned bundling of conductors has been used in Europe for some time. One of the most interesting systems is in Germany where a four conductor bundle is in operation at 300 kv. This has resulted in a lower reactance and reduced radio interference. Many of the German lines traverse heavily populated areas where radio interference is important. While the Germans could not say just how much better the four conductor bundle is compared to twin conductors they point out that it does increase total line costs, including right-of-way costs, by only 2 per cent, and boosts the carrying capacity of long lines from 500 to 600 Mw because of the lower reactance.

In this country bundling with identical 266,800 cm ACSR in lieu of reconductoring with 636,000 cm ACSR was credited with saving $45,000 on a 25.5-mile of 115-kv project on the Pennsylvania Electric system near the new 274-Mw Shawville plant.

Automatic Dispatch

An important development in the operation of large electric power systems is the use of automatic dispatch. Not all systems can apply economic dispatch effectively. On many systems generation and load losses are so closely linked that transmission line losses are not large enough in relation to fuel costs to influence the cost of delivered power very much one way or the other. There are many other systems, however, where the cost of trial calculations to evaluate the incremental transmission losses can point the way to unrealized economies. The proper coordination of incremental generating costs and incremental transmission losses today provides a powerful tool for improving the planning and operation of modern power systems.

An analogue computer developed by General Electric is now in service at the nerve center of the American Gas & Electric system in Columbus, Ohio. Here, it facilitates calculations of the most economical means of generating and transmitting electric power through nearly 8400 miles of high-voltage transmission lines. This system, it is reported had made it possible to effect fuel cost savings amounting to $200,000 annually. West Penn Electric Co. also has installed an automatic dispatch system for its 1750 mile system.

Other Electrical Developments

Among the multitudinous other developments in the field of electrical science and engineering one of outstanding interest and importance was RCA's announcement early in the year of the electronic music synthesizer. This amazing system was demonstrated by General Sarnoff at the Winter Meeting of the AIEE. for its 1750 mile system.

This synthesizer is a means of producing an infinity of new musical complexes employing the sound of human voices and conventional instruments, or tones that may never before have been heard, either in solo performance or blended in any desired orchestral arrangement.

Another development of great potential value if it can be improved are the *light* amplifiers developed both by RCA and General Electric.

Fig. 5. A unique view of the 1520 ft tower near Dallas, Texas, carrying the two antennas for KRLD-TV and WFAA-TV. Known as the candelabra antenna system this twin antenna arrangement solved a difficult problem and is the most unique structure ever designed for television program transmission. Photo Courtesy RCA

In these devices, a light pattern such as a projected television image is amplified by the application of voltage to the elements of a special type of screen. So far light amplification in the ratio of 20 to 1 has been attained. When this figure reaches 100 to one, a practical amplifier of light will be at hand.

One of the most fruitful fields of electrical research today is in the realm of solid state physics — particularly in the field of semiconductor materials. The transistor is less than ten years old — the first public announcement was made in June 1948 — but it is already a significant item in practical communication and control systems. The limitations as to frequency and temperature which characterized the first units are gradually being pushed back, and transistors are now available capable of oscillating as high as 1000 mc.

The smallness of the transistor evidently has spurred electron tube manufacturers to new achievements in reducing the size of tubes. A new concept in tube design was announced and demonstrated in the form of a tiny micro-miniature ceramic triode for uhf-television sets by the General Electric Co. recently. This is an all metal-and-ceramic tube about $\frac{3}{4}$ in. long and 5/16 in. in diameter. An important feature of this little tube is its ability to withstand high temperatures. The exhaust and sealing techniques used in manufacture of the tube enable it to withstand temperatures in excess of 700 C. While the cathode is normally heated with a filament in the conventional manner, a demonstration with a blow torch applied to the outside of the tube showed how it also would operate when heated by an external source.

Closely related to transistor development is the work that is going on in the development of silicon and other semiconductor type of rectifiers. Westinghouse has produced new small silicon diodes capable of handling kilowatts of power. These may usher in a new era of industrial power rectification. These new diodes have a typical voltage drop of only 0.7 volt at a current of 8 amp and at a cell temperature of 190 C. The new rectifier when mounted in a finned cage 1 in. high and $1\frac{1}{2}$ in. in diameter and having natural convection cooling with 65 C ambient, is 15 amp at 200 v peak inverse. Compared to this, a selenium rectifier capable of carrying 15 amp at this ambient would require plates of 45 sq in cross section. Seven such plates in series would be necessary.

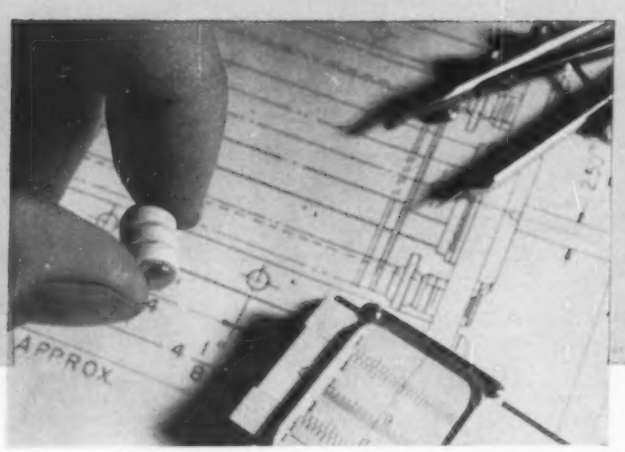
Germanium rectifiers are also growing in size and power capacity and applications include its use in the chemical, aluminum, steel, titanium, and tin reclaiming industries. Units having ratings of 16,000 amp at 65 v, 12,000 amp at 130 v, and 40,000 amp at 24 v are being manufactured. These rectifiers have unusually flat regulation curves and efficiencies run close to 95 per cent above 35 per cent of normal load.

Communication

In the field of radio communication, the most promising development during the year is in the strides that have been made in the transmission of uhf signals over distances far beyond the horizon. This involves what is known as scatter propagation.

At the present time, as is well known, UHF signals are not normally transmitted over distances beyond the horizon. In most of the microwave radio systems the relay stations are spaced about 30 miles apart. This has been thought to be the only practicable means of transmitting by radio the wide bands needed for television and multichannel telephone service. This belief was disproved after years of research at MIT and Bell Telephone Laboratories and by the latter's operation of the transcontinental microwave systems. Frequently it was found the UHF signals went far beyond the horizon. The next step was to provide reliable long distance transmission over the horizon and this was done by erecting much larger antennas and using much higher power than is used in the conventional microwave systems. In order to make use of this over-the-horizon transmission, 10 kw transmitters and 60-ft diameter antennas are being used. This is 20,000 times the power and 30 times the antenna area used in the present transcontinental microwave systems.

In another direction, a new and radically different medium for transmitting television and telephone signals over long distances has been used successfully by Bell Telephone engineers recently. The new medium,



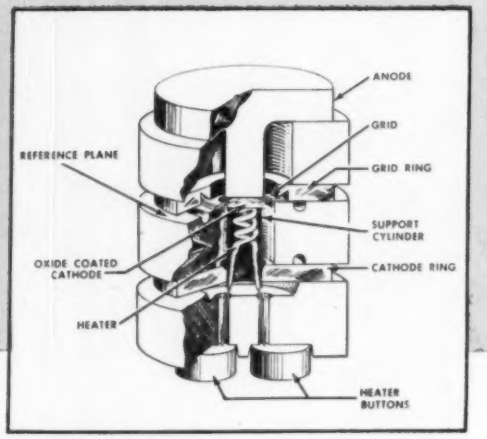


Fig. 7 and 8. One of the most interesting developments in the design of electron tubes last year was the micro-miniature ceramic triode announced by General Electric. At the left is shown a photo indicative of its very small size and at the right is a diagram showing its internal construction. It is able to operate at temperatures up to 700 C

a long distance wave guide, is markedly different from modern cable or radio relay systems — it uses a hollow metallic tube roughly two inches in diameter. Bell Telephone scientists believe that the new waveguide may some day simultaneously carry tens of thousands of cross-country telephone conversations along with hundreds of television programs. Waveguides made of solid metal tubing have been in use for many years for short distances. It would be possible to use these tubes for long distances if they were perfectly straight, but this is impractical. The new long-distance waveguide is also a hollow tube, but it is constructed of thin copper wire, very tightly coiled — like a spring under pressure — and wrapped inside a flexible outer coating which holds the coiled wire in place. This type can actually carry signals around corners.

Still another advance in microwave transmission is the development of the horn-reflector antenna by Bell Telephone engineers. The first installation of this type antenna was made during the year at a station near Terrell, Texas. Horn-reflector antennas which are to replace the so-called delay lens antennas used on most Bell System relay routes, operate over a very broad frequency band. Eventually it will be possible for this antenna to handle 15,000 telephone conversations and ten television programs at the same time.

Of unusual interest in the field of antenna construction was the erection of the Hill Tower and the RCA Candelabra for Dallas' two highly competitive TV stations — KRLD-TV and WFAA-TV. These rival stations decided, almost at the same moment, to move to new locations and put up new towers designed to achieve the greatest possible coverage, so everyone sat back to watch the fireworks. This wasn't something simple — like Texas against the world. This was Texas against Texas — and the sky was the limit.

But the sky wasn't the limit — 1521 feet was. And even in Texas 1521-ft towers are mighty expensive. Moreover, there was only one best location. So, why not build a single tower for both stations. Even the Hatfields and the McCoys (the respective owners) could see the sense of that, not to mention a saving of half-a-million dollars in cold cash.

There was only one question. Who was to be top dog on the tower? A little extra coverage and a lot of Texas pride was involved. Neither side would give an inch. Faced with this dilemma the engineers of the two stations huddled with engineers of the RCA antenna group, and they came up with an idea the like of which was never seen before — not even in Texas. Dubbed "the candelabra" it consists essentially of a tower-top platform on which the two antennas are mounted side-by-side.

After much investigation and research involving the building of models, it was decided to go ahead. The result was the tremendous 1435-ft main tower topped by the 82-ft, 9-in candelabra structure. The top structure is a triangular platform, 80 ft across on each side. Two of the corners carry the antennas while the third is counterweighted to keep the platform in balance with a 10,000 lb scrap steel counterweight. In many ways — structurally as well as electrically — this antenna is a remarkable achievement.

Superconductive Computers

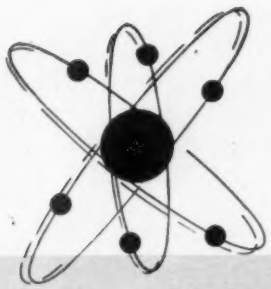
Among the new applications of basic scientific discovery an extremely interesting one that came to light this year was the one involving the first practical application of the use of superconductivity in electrical conductors. This work, which was carried on at MIT involves the use of superconducting elements in computer design. It makes possible the design of extremely small and compact electrical computers, so compact, in fact, that exclusive of the refrigeration equipment needed to supercool the unit, the components of a large-scale digital computer can be made to occupy one cubic foot. The elements used are called cryotrons.

In its simplest form it consists of a straight piece of wire about one inch long with a single layer control winding wound over it. Current in the control winding creates a magnetic field which causes the central wire to change from a superconducting state to its normal state. The device has current gain, that is, a small current can control a larger current and it has power gain so that cryotrons can be interconnected in logical networks as active elements. In practice the elements are immersed in liquid helium to attain the superconducting state.

When in this state, the active elements have zero resistance. The phenomenon of superconductivity was discovered in 1911 by Kammerlingh Onnes at the University of Leyden in Holland, three years after he succeeded in liquifying helium.

While entering electrical resistance measurements to this new low-temperature region he found that the resistance of many conductors drops suddenly to zero at a few degrees above absolute zero. This state he called superconductivity. Later, it was shown that when a magnetic field is applied to a conductor in the superconducting state, the onset of superconductivity occurs at lower temperature. This, then, is the principle of control involved in the design of the computer elements developed at MIT. The extreme compactness of the units coupled with the low power requirements and the relatively low cost of the refrigeration needed give this development attractive possibilities in the design of future computers.

Nuclear Power Plant Control Is Different



Basically the control problem in the design of an atomic power plant is the same as in conventional plants but the presence of the nuclear reactor in the system imposes many unusual design and operating problems upon it

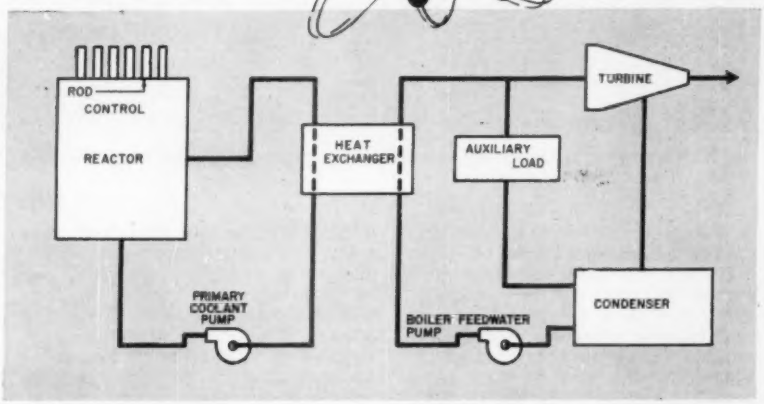


Fig. 1. Illustration shows elementary block diagram of a nuclear power plant

By R. R. TAGGS

BASIC RELATIONSHIP between the nuclear reactor and the atomic bomb has caused a certain amount of apprehension concerning the dangers of power reactors in populated areas. While this feeling is understandable, actually there is little cause for concern. Reactors are quite different from atomic bombs. Not only is the fissionable material different from that used in nuclear weapons but the reactor is totally inadequate as a bomb casing. There is, however, need for extremely reliable and sensitive control of nuclear reactors since reactors may contain sufficient fuel for several months or years of operation, and in case of failure this great amount of potential energy would constitute a source of great danger.

The procedure for designing the control system of an atomic power plant is basically the same as for any other type of power plant, but the presence of the nuclear reactor as a component part of the plant imposes many unusual design problems. The approach to the design of the control system consists first in studying the tentative plant operation and control requirements. Following such a study, a preliminary block diagram of a control system to fulfill these requirements may be attempted. This will disclose the inherent dynamics of the plant and the characteristics and limitations of some of its components. The block diagram can then be modified to more closely fulfill the control requirements. Once the desired operation of the control system is understood, the problem of developing the system can begin.

An elementary block diagram of a planned nuclear power plant is shown in Fig. 1. Here the reactor is considered merely as a source of heat energy. This heat is extracted by passing a coolant through the reactor. The coolant, in turn, transfers the heat energy to a turbine by means of a heat exchanger, which also serves as a steam generator.

The type of coolant or heat transfer medium is important in the design of the control system and various types are in use. These include gas, water, and liquid metals. In some designs the heat transfer system involved two loops and two heat exchangers, a primary loop in which the coolant is highly radioactive, and a secondary loop in which the heat is transferred to the steam generator.

The nature of the electrical load is important in the design of the control system. A useful principle in the design of the system is to attempt placing the primary controller near the output of the power system. The characteristics of the load with respect to turbine capacity is, therefore, of first interest. Then, whether the final output is to be continuously variable, adjustable in steps, or a combination of these two methods.

Start-up and Shut-down

Start-up and shut-down requirements affect the nature of the control system. Here the nuclear reactor plays an important part in determining plant performance for a nuclear reactor cannot be energized suddenly, any more than can a steam boiler, and it can never actually be shut down. In considering the output of the nuclear reactor, there is no such term as *zero-power* involved. Even in a new, cold, clean reactor an inherent source of neutrons exists which causes a certain amount of nuclear fission among the uranium atoms. This fission produces minute amounts of thermal energy, and in the process more neutrons are produced — a snail-pace chain reaction.

Thus, the reactor neutron output must be monitored continuously so that this neutron level can be kept under observation and control. This means that the instruments for measuring the neutron level must have a wide operating range, possibly as wide as 6 to 10 decades, and the control mechanisms must have a similar operating range. Starting a reactor up from *cold* means that it will have to operate over a range of many decades before appreciable power begins to make itself apparent at the output stage. Some arbitrary value of neutron intensity is generally accepted as *zero* power. For example, one per cent of full-load output might be considered as the equivalent of zero power. Transitions between one and 100 per cent plus full power can be made relatively rapidly but, because of the safety aspects involved, transitions from a cold start-up must be made gradually over a period of 5 to 15 minute increments.

A reactor which has been operating at a high power level is turned off by inserting the control rods into the core of the reactor. The control rods have a high neutron absorption capacity and their presence thus reduces the number of neutrons available for the fission of uranium atoms. The control rods, however, have no effect on the secondary radiation which still exists — the gamma and beta rays resulting from the continuing disintegration of the fission products. This radiation in some cases produces a substantial amount of heat energy which may be emitted

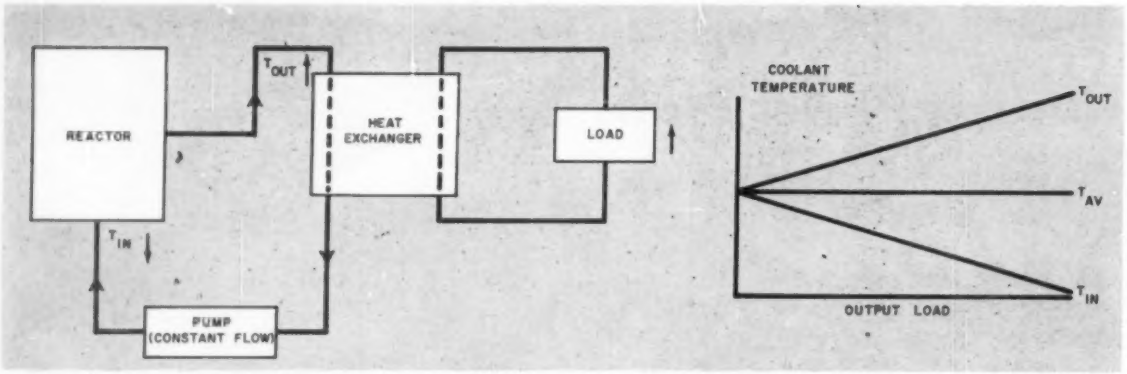


Fig. 2. Power plant diagram with reactor having negative temperature coefficient

Fig. 3. Steady-state temperature pattern

for a considerable length of time after the reactor has been turned off.

It may, therefore, be necessary to provide auxiliary control devices to dump this spare energy into a sink or, if feasible, into some plant facility capable of consuming it economically. Therefore, the starting and shutdown of a nuclear power system is dependent upon the reactor characteristics, and in this respect it differs from conventional plant practice.

The transient output requirements of the plant are also of some importance. During operation it is likely that certain peak demands will be made on the system. These demands are similar to those made on a conventional plant whereby above-rating performance can be obtained for a short time. Probability of such peak demands in relation to normal operating level must be analyzed.

Reactor Poisoning

The design of the system with regard to reactor poisoning is another factor of importance and this has no counterpart in the design of a steam or oil-fired boiler. When a reactor operates, a variety of fission products are produced. These fission products are the fragments of the split uranium atoms and they comprise many elements with atomic numbers somewhere near the center of the periodic table of elements.

Among these fission products are certain nuclei with large *cross-sections* for the capture of thermal neutrons, hence they act as poisons. These nuclei may be either direct fission products or they may result from the decay of the latter. The rate of their formation depends upon the fission rate in the reactor, while their removal is determined partly by natural radioactive decay if radioactive, and partly by capture of neutrons which leads to a change of identity.

Thus, some of these radioactive poisons build up after a reactor is shut down. In time, of course, they die away, but before they do, they accumulate to a point where it may be impossible to re-start the reactor until a certain period of time has elapsed. To counteract this a certain amount of additional reactivity can be built into the reactor to *override* this poisoning effect. Thus, the amount of poisoning neutralizing action which is built into the reactor becomes an operating factor because with only a small amount of override the poisons can build up in a given amount of time to make it impossible to re-start the reactor if it should be shut down temporarily.

If, before this condition is reached, the reactor is turned back *on* (the control rods extracted) the poisons may be effectively neutralized and operation of the reactor will be unimpaired. If, however, the poisons have built up to such a level that the reactor cannot be energized, then it becomes necessary to wait for the poisons to dissipate — literally die of old age — until the reactor can again be made critical.

To build enough reactivity into a reactor to substantially over-ride the poisons may require a large amount of additional fissionable material. If the service to which the plant power is put is such that the entire plant must be shut down frequently for indefinite periods, then some other means must be found for supplying auxiliary power during the off-time of the reactor.

Still another factor involved in the design of control components is the reactor and plant lifetime. Contrary to popular belief, reactors do not possess indefinite life nor unlimited charge. The uranium atoms involved in the fission process become spent, and although a tremendous quantity of energy is produced each instant an atom is split, ultimately enough fission-time occurs so that the reactor becomes depleted. Then it will no longer maintain a chain reaction.

Other effects such as radiation damage to the reactor structure, corrosion in any part of the system, and the continued build-up of the neutron-absorbing poisons already mentioned, all may affect the life of the reactor. If the design of the plant can be engineered so that all components have an effective lifetime comparable with that of the calculated life of the reactor proper, then continued operation over long periods will involve only the changing of fuel assemblies from time to time.

Once the overall characteristics of the plant have been specified, details of these characteristics pertinent to the control system can be considered. At this time detailed information is needed about the steady-state output error that can be tolerated, that is, how important is it that the plant be capable of delivering a fixed power output regardless of operational transients? The steady-state output error determines the tolerable steady-state plant instrument errors.

Frequently control systems are devised in which the errors of many instruments in different loops add up to produce a higher probable error than specifications permit, or indicate a higher error than actually exists in the system. On the other hand, it is possible in the design of component elements of a system to cancel instrument errors so that they do not appear in the final output. From the overall error permitted, the designer can work backwards through each loop computing the steady-state error that conventional control components will impose on the system.

Scram Circuits

One control requirement peculiar to the nuclear power plant is the instrumentation setup for alarm, cutback, and *scramming* circuits. Alarm and annunciator circuits are common to the power industry but the peculiar notion of a *scram* is limited to the reactor field. A scram in reactor parlance consists in reducing the reactivity of a reactor with almost explosive suddenness. Practically, a scram means injecting safety rods into the interior of the reactor with some violence.

The safety requirements of both personnel and equipment are such that it is necessary to employ scramming devices. From an operating standpoint, however, it is obvious that the plant must be kept in opera-

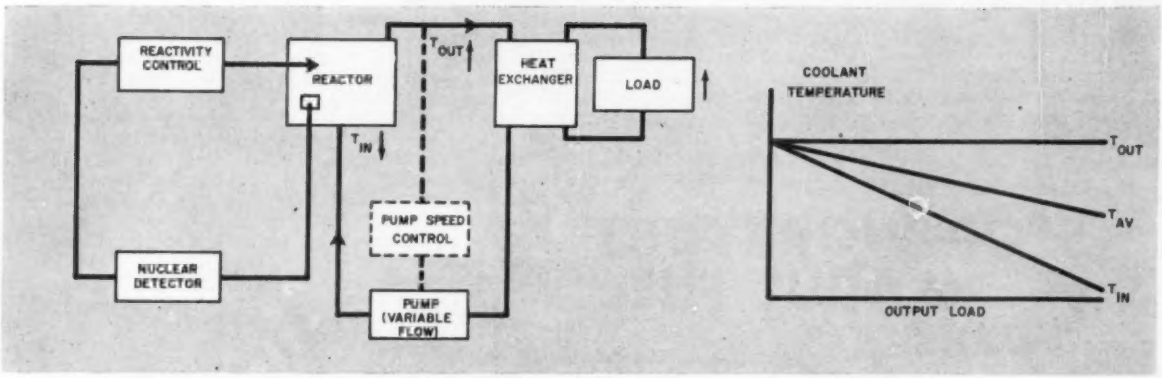


Fig. 4. Diagram showing system maintaining primary coolant temperature constant

Fig. 5. Steady-state temperature pattern

tion as continuously as possible. It should not be necessary to shut down the plant for every minor trouble in one of the secondary loops.

The control designer's problem is to limit the number of controls which can initiate the scram to an absolute minimum. For all contingencies other than the type requiring a scram, it is possible to cut back the reactor power level by making the necessary adjustments manually or automatically through the ordinary supervisory control equipment.

Effect of Temperative Coefficient

The heart of the control problem in the operation of an atomic power plant is the primary cooling system operating cycle. There are many patterns into which the temperature, pressure, and the flow in and out of the coolant may be arranged and there are many factors which determine these patterns.

In the design of a nuclear power plant, one should attempt to follow this basic principle: *If the reactor has a negative temperature coefficient, the reactor system preferably should have the average coolant temperature constant.* Concerning this term, negative temperature coefficient, it means simply that as the reactor's average temperature increases, its overall reactivity decreases. In other words, chain reaction will slow down with increasing temperatures; this semi-automatic behavior is desirable.

Consider the simple plant illustrated in Fig. 2 in the light of this principle. This diagram shows the primary coolant being circulated at constant flow through a reactor having a negative temperature coefficient. A steady output is being produced. Now, suppose that additional output is demanded by an increase in load. This additional loading will cause more heat to be extracted from the heat exchanger and for a short period of time the storage capacity of the heat exchanger can usually supply this energy — similar to the way the kinetic energy stored in a flywheel provides the additional power required in a press operation. However, this extra energy extraction from the system will drop the temperature of the coolant flowing into the reactor. If, under these conditions, the reactor has a negative temperature coefficient, the reduction in coolant temperature increases the reactivity of the reactor.

If the reactor was initially in a critical state it now becomes supercritical. More energy is then available from the reactor; consequently the temperature of the coolant rises and the reactor returns to its critical condition with the average coolant temperature the same as it was originally. These steady-state temperature conditions are shown in Fig. 3. It will be noted that without any control mechanism whatever the reactor system has stabilized itself about a given average temperature and automatically supplied any reasonable demand put upon it. This is the case only where the average coolant temperature remains fairly constant.

Assume now that for some other reason than reactor control, it is desirable to establish a different pattern of coolant temperatures. A reasonable pattern might be that shown in Fig. 5. Here the outlet temperature is fixed at a given maximum level. Figure 4 is a block diagram of a system whereby this condition might be achieved. Again, if more load is required, the inlet temperature of the reactor tends to drop. This results in an increase in the reactivity of the reactor because of the negative temperature coefficient.

The outlet temperature would tend to rise, but now a control has been inserted on the outlet temperature which varies the coolant-pump speed in such a manner as to reduce this outlet temperature if it tends to rise. In this manner it is feasible to hold the outlet temperature constant as a function of the load as in Fig. 5.

However, it will still be noted that the average coolant temperature drops as the load increases which means that the reactor, because of its negative temperature coefficient, would tend to operate in a supercritical condition. Consequently another control loop, usually rod control, must be added to the system to neutralize the reactivity developed by change in coolant temperature.

The system of Fig. 5 from a control standpoint compares unfavorably with the previous system because the external control devices cause the reactor to operate in a manner contrary to its own inherent stability. This puts the system in a less safe condition and requires considerably more control equipment. Neither of these simple systems is completely practical for an actual plant but many variations can be developed for specific requirements.

Miscellaneous Factors

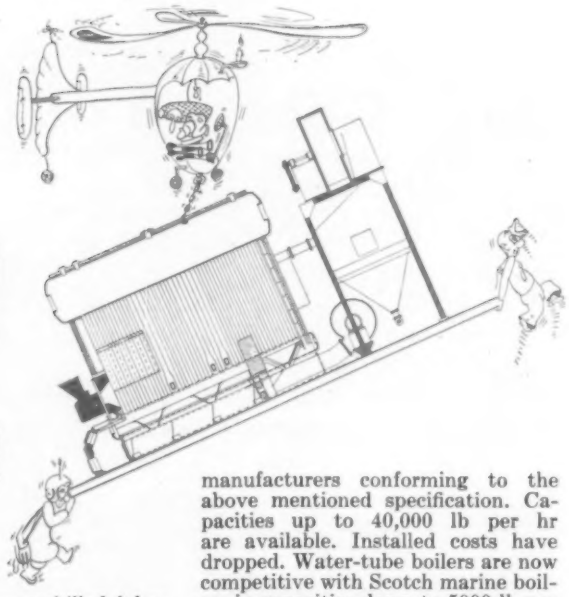
There are many other bits of information to be considered in the development of a nuclear power control system. The character of the coolant system is of great importance. For example, in systems using water or gas as the heat transfer medium it will usually be necessary to pressurize the main coolant system. Operating a loop under pressure calls for pressurized heaters, pumps or blowers, and controls.

As far as the turbines, generators, condensers, pumps, and other power plant auxiliary equipment are concerned, these bear the same relationship to the control system in a nuclear power plant as they do in a conventional fuel-fired plant. What makes the nuclear plant different is the reactor. Purpose of the reactor is the same as the coal or oil fired furnace but its characteristics are very different.

One reason for this is that in most nuclear reactors the entire fuel supply for many months or even years is contained in the reactor itself. As such it constitutes a potential source of danger in case something happens to make it run away. A nuclear power reactor is unlikely to explode but if the controls should fail, the temperature could rise to such an extent that the fuel elements would melt or vaporize and in that case a great deal of dangerous radiation would be released. It is for this reason that the control system is so important.

STOP WORRYING ABOUT FUEL

... with the "Weekend Convertible", Navy's low-cost, quick-change, small dual-fuel, water-tube package boiler



ANOTHER milestone in small boiler practice has been reached — a dual-fuel water-tube packaged unit at prices competitive with oil or gas firing alone. A score of engineers representing various industries and government agencies gathered at Wilkes-Barre, Pa. on November 11 to see the first steaming tests.

On what had been a bare concrete slab on Monday night, the boiler had been set, dried out, boiled out, hooked up and was carrying a heavy overload by Friday noon. It was stoker fired with bituminous coal but can be converted to oil or gas firing in less than 60 hr, a period specified to permit conversion over a weekend. Costs for size ranges of from 10,000 to 25,000 lb per hr are expected to run from $2.50 to $3 per lb of steaming capacity.

The development program was a Navy project which had been under way for several years. The Navy is the World's largest user of stationary boilers. First cost is of greater concern than it normally is with industry.

There is also the problem of peacetime economical operation with cheap or dump oil and gas and the knowledge that in wartime only coal, probably a low-grade local coal, will be available.

Navy Passes—Air Force Receives

To solve the problem, the Navy studied it together with the boiler industry and eventually drew up specifications. Two design contracts were awarded, one to Superior Combustion for a range of capacities from 10,000 to 22,500 lb per hr in 2500-lb increments, one to Foster Wheeler for a range of sizes from 25,000 to 45,000 lb per hr in 5000-lb increments.

Both specifications call for a flat slab foundation and a design adaptable to stokers built by several manufacturers. The larger sizes cannot be shipped as a single package but all components are designed to be bolted together in field by unskilled labor.

A prototype boiler of the larger size has not yet been built by Foster Wheeler but the first one will have a rated capacity of 30,000 lb per hr. Two of the smaller type were built by Superior Combustion on contract with the Navy for the Klamath Falls Air Force Base in Oregon. The Navy, being administratively equipped to assist other departments, constructs some plants for the Air Force.

The first unit tested, and shown by Fig. 2, is rated at 12,500 lb per hr at a working pressure of 125 psi saturated. Essentially it consists of four units or elements: the Superior Combustion type A boiler proper with accessories, furnace brickwork, bridgewall and ash hoppers; the Riley vibrating grate stoker with the grate line but 21 in. above the floor line; the Rimcor metering combustion control equipment and panel; and the flue gas section as shown by Fig. 1.

The latter consists of a Buell dust collector, a Sturtevant induced draft fan and a stack, the complete unit being designed to bolt to the boiler breeching and to be erected by unskilled labor. Forced draft, overfire air and fly ash reinjection equipment are part of the package.

Navy experience in the small boiler field was outlined to the ASME recently by LeRoy F. Deming who heads the Power Generating Section. He said: "Oil-fired water-tube boilers in the smaller capacities were found to be too costly in comparison with the Scotch marine boiler. The Navy's standard specification for the procurement of factory-fabricated package-type water-tube oil-and-gas-fired boilers was developed. It is now the standard specification for the Department of Defense under the Number MIL B-17095B. When this specification was born, the results were amazing.

"Available sources have increased from three or four to not less than 11 manufacturers conforming to the above mentioned specification. Capacities up to 40,000 lb per hr are available. Installed costs have dropped. Water-tube boilers are now competitive with Scotch marine boilers in capacities down to 5000 lb per hr in some cases and almost without exception in capacities of 12,000 lb per hr and above, using standard Navy specifications in each case.

Mr. Deming also gave a great deal of attention to costs. One recent instance was in an area where both coal and oil are potential fuels. The Bureau recommended certain modifications in the engineers' design to adapt it for the future installation of coal and ash handling equipment, spreader stokers, and dust collectors.

This plant, consisting of two water-tube boilers each of 60,000 lb per hr

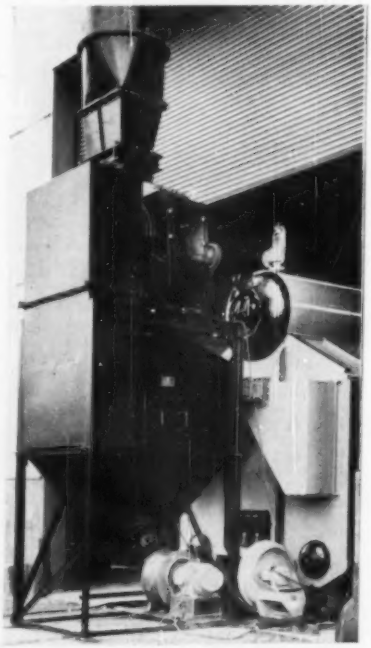


Fig. 1. Stack, dust collector, forced and induced draft, overfire air and fly ash reinjection are part of the package

capacity has a total contract price of $3.79 per lb of capacity not including the cost of engineering and site.

A second plant of the same capacity differed but slightly. The dual-fuel firing equipment was part of the initial installation. Mechanical ash discharge spreader stokers with coal and ash handling equipment and dust collectors were part of the initial installation, as were oil firing and storage facilities. The contract price of this second plant was $7.64 per lb of capacity not including the cost of engineering and site.

Said Mr. Deming, "This is 202 per cent of the cost of the former plant. Location is different, labor costs may vary slightly, but basically the difference in design is responsible for the difference in cost. The Navy gets nothing more in the second case than the first except facility to burn coal.

202 Per Cent Costs Excessive?

"The Bureau considered that this difference, $3.85 per lb of capacity represents an excessive cost for this added facility. The tendency is to load the cost of the coal-fired plant. A recent coal-fired plant consisting of three 90,000 lb per hr boilers cost $6.55 per lb on the same basis . . .

"The Navy concept of dual-fuel firing equipment is that facility which can be converted from the economical use of one fuel to the economical use of an alternate fuel without interrupting boiler output for more than 60 hours. This permits conversion over a weekend. In such cases one of these fuels is coal."

In the absence of special architectural requirements, the Navy considers standard building of structural steel frame with transite or equivalent sheathing. This plant is designed for operation with a minimum crew. Two men on the daylight shift and one man on each of the night shifts should constitute an adequate operating crew in usual heating plant service. This does not include unloading of coal and ash disposal.

Equipment is designed for minimum wear and maximum dependability and is arranged to facilitate inspection and both preventive and operational maintenance. All operation is mechanical. Silos are designed for the free movement of coal, even to the extent of heating facilities to prevent arching of wet coal or freezing in coal weather.

"and air heater cost . . ."

The cost of a plant of this type with two 60,000-lb-per-hr boilers without air heaters is estimated at: 1, for oil fuel only — $3.95 per lb; 2, for coal fuel only — $5.00 per lb; and 3, for dual fuel firing — $5.35 per lb. To the above costs should be added approximately 40 cents per lb if air heaters are installed.

Commenting on the design details of the unit before the same audience, Frank F. Hohnholt said: ". . . there is nothing new in the form of equipment being employed in this packaged generator. In fact, there have been many installations of packaged generators of this or other types where the boiler was set upon a brick base anywhere from 3 to 5 ft in height.

"Particular attention was paid to furnace volume in the area of the grate and burning zone of the furnace. Gas velocities in the furnace entering and leaving the tube bank were also major considerations. An adequate reinjection and overfire air system has been employed. This is not just a hit-and-miss arrangement, as is common where a packaged boiler, normally sold for oil or gas firing, is set high on a refractory base as shown in Fig. 2.

"Use of a high refractory base is expensive both in first cost and in maintenance. . . . Note that the base for this package boiler is only 15 in. high and that a chill line exists at the grate or fuel burning level. The arrangement of converting this boiler from solid fuel firing to liquid firing was required to be accomplished in a period of 60 hr. Here again, no hit-and-miss arrangement is employed.

. . . a New Front

"The entire stoker feeder and front plate is a separate section bolted into the boiler front plate. Replacement of this feeder and its hopper with a similar section of front plate which includes a windbox and burner will convert the firing equipment. The balance of the conversion is simply one of covering the grates with suitable ceramic materials and opening the plenum chamber under the grates to admit the air to the windbox for the firing of the oil.

"A practical economical installation of a coal-fired packaged steam generator became possible with the development of the continuous discharge vibrating grate type of stoker. The use of this form of equipment eliminated many of our problems. . . .

"If the oil and gas fired water-tube package steam generator is a precedent, perhaps the time is not too long distant when manufacturers of water-tube package steam generators will be able to offer boilers of this type at figures of $2.50 to $3.00 per lb of steam generated, delivered to job site which, of course, is approximately equivalent to a delivered and erected price."

With all the effort in producing an engineered product, one problem remains to be solved. It was voiced by E. C. Miller of Riley Stoker to the same group. He said "It is probable that ash disposal and coal supply will go hand in hand and will be performed by the coal supplier rather than by the personnel of the small plant." *continued on page 116*

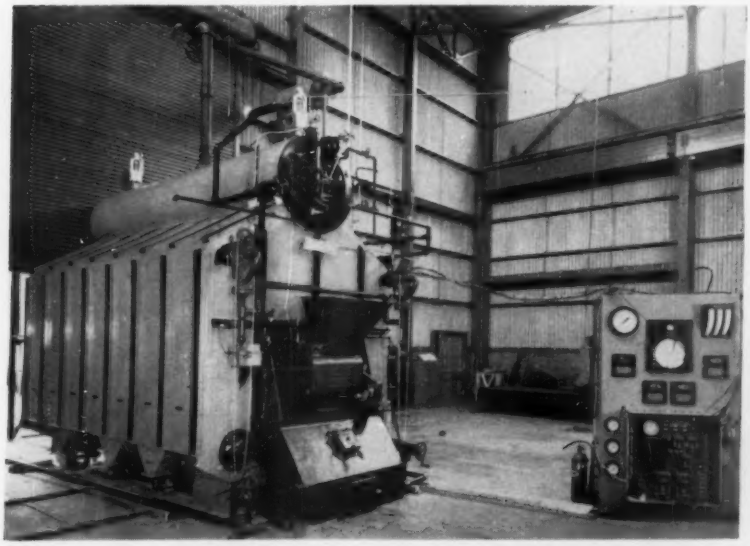


Fig. 2. Monday night the floor was a bare concrete slab. The boiler was set, dried out, boiled out, hooked up and carrying an overload Friday noon. Conversion to oil or gas can be made in less than 60 hr. Cost is less than $3 per lb of steam

Navy Boiler Program

In October, the Fuels Division of the ASME held a joint fuel conference at Columbus, O. LeRoy F. Deming, Head of the Power Generating Section of the U. S. Navy Bureau of Yards & Docks gave a comprehensive paper "Navy Practice of Designing for Dual-Fuel Firing in Shore Steam Stations". This paper reviewed experiences of several years, cited some costs and covered, by text and drawings, standardized plant designs adopted by the Navy.

This was mimeographed and is available from the American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N.Y. Ask for Paper No. 55-FU-4. Price is 50¢ each.

ASME Closes Diamond Jubilee Year With Big Celebration at Chicago

DURING the past year, the American Society of Mechanical Engineers has been celebrating its 75th Anniversary, its Diamond Jubilee Year. Overall theme for the year's celebration was The Engineer in Our World. At a special Founder's Anniversary meeting in February, it celebrated The Engineer and the World of Communications. An April meeting covered The Engineer and the World of Education. The Spring meeting was devoted to The Engineer and the World of Government. The semi-annual meeting covered the Engineer and the World of Science. Climax of the year's celebration came with the annual meeting held in Chicago November 13 to 18, with headquarters in the Congress Hotel, covering the Engineer and the World of Commerce and Industry.

That meeting, attended by over 4000 members of the Society, including several hundred members of the Woman's Auxiliary of the ASME, was replete with emphasis on the role of the engineer in the modern world of industry. There were the usual technical sessions at which some 100 important papers were delivered. Those sessions were unusually well attended. Because of important developments in the power field during the year, there was outstanding attendance at the sessions on power, gas turbines, nuclear engineering, supercritical power plants, turbine metallurgy, furnace performance, boiler feedwater.

The ladies of the Woman's Auxiliary held several notable meetings to which the men were invited; their Early Bird Party and also the Tea Dance drew a record attendance. In addition, the Chicago Section of the Auxiliary planned a most interesting program of luncheons and trips for the out-of-town ladies.

A feature of the meeting was an entire day devoted to the 75th Anniversary Convocation at which James D. Cunningham and Alex D. Bailey were chairmen of two sessions. At one of these, Joseph B. Armitage, Gen. James H. Doolittle, Samuel B. Earle, Simes T. Hoyt, Carl G. A. Rosen and Clyde E. Williams formed a panel to discuss The Economic Aspects of Technology.

At the Honors Luncheon, honors were conferred on William F. Gibbs, Walker L. Cisler, Charles F. Kettering, Philip Sporn and Theodore von Karman. Following that luncheon, the first four of those men delivered important addresses on The Engineer and the World of Commerce and Industry. At this convocation, greetings and good wishes on its 75th Anniversary were presented to ASME by 32 other national professional societies and industrial groups.

Dr. David W. R. Morgan, 1955 ASME President, was toastmaster at the annual banquet, which was attended by a total of over 1300 members and their wives. Dr. Morgan officially introduced Dr. Joseph W.

Annual ASME Meeting Papers of Interest to Power Engineers

The Editors have prepared short abstracts of these papers to help you decide whether or not you want to obtain complete copies of them from ASME at a nominal price.

For a mimeographed copy of these abstracts, write the Editors or jot ASME Abstracts on the postage-free card elsewhere in this issue. DO NOT send us any money. When we send you the abstracts, we'll tell you where to get the complete papers, and their price.

Tests of an experimental coal burning turbine

The supercharged-and-intercooled free-piston-and-turbine compound engine—a cycle analysis

Some design aspects of the free-piston gas-generator-turbine plant. Part I. Thermodynamics and component characteristics. Part II. Controls and accessories

Effect of turbine blade cooling on efficiency of a simple gas turbine power plant

Pulsating, pressure generating combustion systems for gas turbines

First commercial supercritical pressure steam-electric generating unit for Philo plant

Combination gas turbine and steam turbine cycles

Experimental superheater for steam at 2000 psi and 1250 F—report after 14,281 hours of operation

Design of a large coal-fired steam generator for 200 F exit gas temperature and operating procedure with pilot plant

High temperature corrosion of alloys exposed in the superheater of an oil fired boiler

The filtration of No. 6 fuel oil to remove undesirable trace metals

Upgrading burner performance of distillate fuel oils by hydrogen treatment

Improvement of distillate fuels by additive and refining techniques

Combustion calculations for multiple fuels

Fly-ash refiring in a new type of furnace

The sintering test—an index to ash fouling tendency

Ash deposits on boiler surfaces from burning Central Illinois coal

Design improvements in industrial electrical motors and controls

Plant management and other factors affecting maintenance costs in steam generating stations

Maintenance factors affecting production costs

Maintenance control in steam power plants

A system of charging for steam in industrial plants with power generation

Photo identifications read left to right

Primer Movers Committee award winners for contribution to ASME symposium on outdoor power plants: W. F. Friend, Ebasco; F. W. Argue, Stone & Webster; L. Elliott, Ebasco; E. C. Duffy, Long Island Lighting; B. G. Skrotzki, Power

At session on high temperature steam generation (left to right): Wilson R. Erskine, John H. Hoke, Bela Ronay, William E. Clautice, H. L. Solberg, F. Eberle, R. J. Roudebough, William E. Somers and Lyle B. Scheuler, the Vice Chairman

Barker, incoming ASME President for 1956. Many honors were conferred on members for outstanding achievement; and one of great interest to power engineers was the Prime Movers Committee Award for a symposium on Outdoor Power Plants, made to Fred W. Argue, Edward C. Duffy, Louis Elliott, Walter F. Friend, Gustaf A. Gaffert (posthumously) and B. G. A. Skrotzki.

Entire tone of the meeting was one of great enthusiasm and promise for further achievements by ASME in carrying out its Anniversary motto: By Truth and By Service to Enrich Mankind. Special praise was given to the valuable services being rendered to the Society by the Woman's Auxiliary.

For the Chicago Section of ASME, hosts to the annual meeting, James D. Cunningham and Alex D. Bailey were chairman and co-chairman respectively of the executive committee, with Robert H. Bacon as general arrangements chairman and Charles W. Parsons as committee secretary. Technical program chairman was John T. Rettaliata; entertainment and hospitality chairman was Arthur B. Openshaw; annual banquet committee chairman was William A. Dundas. Mrs. Alexander Cowie was chairman of the Ladies Committee of the Chicago Section, of which Mrs. Frank P. Lawler is president.

Following are highlights of the technical papers presented at the annual meeting that are of most interest to power engineers:

Concern of power engineers over turbine failures occurring in the last two years was emphasized by the large attendance at the metals engineering sessions describing these failures and the steps taken to prevent their recurrence in the future. The main points of these discussions have been covered elsewhere in this issue.

Fuels Division

Papers on fuels covered a large range. C. H. Shields, Jr. described an effective method of removing trace metals from No. 6 fuel oil by filtration using diatomaceous earth. R. P. Gilmartin, W. A. Horne, and B. R. Walsh, discussed a new hydrogenation process used in the manufacture of No. 2 fuel oils and described some of the changes in fuel properties and burner performance resulting from hydrogen treatment.

Tibor Buna presented a detailed procedure for calculating analysis and heat content of several fuels fired in combination, while Charles H. Marks presented results on the flow characteristics of crushed coal when passing air through a bed of such coal.

Left to right: Gen. James H. Doolittle, Vice-President, Shell Oil Co.; Joseph B. Armitage, Vice-President, Kearney & Trecker Co.; Carl G. A. Rosen, Consulting Engineer, Caterpillar Tractor Co.; Clyde E. Williams, Director, Battelle Memorial Institute, Columbus; C. E. Davies, Secretary, American Society of Mech. Engineers

Burgess H. Jennings, Chairman, Dept. of Mechanical Engineering, Northwestern University; C. D. Moriarty, General Electric Co.; Adolph O. Schaefer, The Midvale Co.; A. W. Rankin, General Electric Co.; R. E. Peterson, Westinghouse Electric Co.; M. L. Machel, Westinghouse Electric Corp.; C. Richard Soderberg, Dean of Engrg., M.I.T.; J. D. Conrad and D. W. Gunther, of Westinghouse Electric Corp

Steam Generation

Messrs. Wingert and Stanley gave interesting details of studies leading to the decision to design Detroit Edison's River Rouge No. 3 boiler for an exit temperature of 200 F, while John H. Hoke and F. Eberle gave results of the metallurgical examination of various superheater alloys producing steam at 1250 F for 14,281 hours. McDowell, Raudebaugh, and Somers gave interesting data on a series of heat resistant alloy test racks containing some 30 odd specimens installed in the gas inlet of the second bank of the superheater in a Public Service Electric and Gas Company boiler where gas temperatures ranged from 1560 to 1100 F.

Maintenance controls and costs came in for a good deal of attention at the conference. Three papers of particular interest were given on this subject.

V. F. Estcourt, General Supt. of Steam Generation, Pacific Gas & Electric, brought out the importance of replacement power costs in the over-all cost picture of the repair job. This, he emphasized, can easily cost much more than the repair job itself. He spoke also of the need to study those factors which influence the ability of equipment to stay on the line.

W. F. Oberhuber and C. W. Watson of Philadelphia Electric Co. discussed the major factors that they believed contributed to the level of

S. N. Fiala, Chief Engineer, American Gas & Elec Corp; F. G. Feeley, Jr., Purchasing Agent, Carbide and Carbon Chemicals Co.; H. E. Crossley, Scientific Advisor, British Cen. Elec. Authority and James W. Myers, U. S. Bu Mines

Charles H. Shields, Jr., General Electric Co.; Donald L. Jordell, Dept. of Mines and Technical Surveys of Canada; P. R. Broadley, L. D. C. Dunkirk; A. Matuik, of Burns & Roe, Inc.; C. M. Gardiner, GE; Seymour Baron, Burns & Roe, Inc.

maintenance costs. They listed design, management, planning, organization and an information-gathering system as important contributors to the maintenance problem and called for more study and discussion of this subject.

G. V. Williamson, of Union Electric, Missouri, described their experience with an economical maintenance program which stresses over-all system economy rather than dollar maintenance costs. The company has given the subject much accounting and engineering study, including a ten-year program of detailed cost records for hundreds of individual equipment items.

L. J. Sforzini and C. A. Winslow, Jr., of Eastman Kodak, proposed a system of charging for steam in industrial plants.

Gas Turbines

Many papers were delivered on gas turbines, their variables in design and operation, and their influence on other power cycles. An excellent paper delivered by Messrs. Mayers, Matiuk and Baron of Burns & Roe, Inc., investigated the heat rates and economies offered by combined steam-gas turbine plants. They concluded that with equipment already developed and proved, combined plants can be built with 3½–6 per cent better heat rates than steam plants attain, at lower fixed costs, and with a high reliability. Comparable heat rates (8354 to 8577 Btu per kwh) could be attained only by going to supercritical steam pressure, steam temperatures above 1050 F, and multiple steam reheating.

McGill University's Mordell and Foster-Pegg gave operating experience on a working exhaust-heated coal burning gas turbine. Their conclusions are not complete in a commercial sense, but they believe the new unit to be entirely feasible technically. Exhaust-heated gas turbines compress air; heat it in an "air boiler," and expand it through a turbine; the exhaust from this turbine is used to burn coal (in this case) at about atmospheric pressure. Thus, no products of combustion pass through the turbine itself and maintenance is confined mostly to the air boiler. Peak over-all efficiency was only 14 per cent, which would compete with other gas turbines because the unit burns inexpensive coal. The question remains; will design improvements make it competitive with coal-burning steam plants? Perhaps it will.

Free-piston gas turbines were considered by S. L. Soo and W. A. Morain in two papers jointly presented. The interesting part of these papers was the fact that f-p units are accepted therein as working prime movers which can stand a little more component development. This is the status of the diesel and gasoline engine, and many of the conclusions reached for the f-p units are equally applicable to supercharged or compound crank-type engines. Supercharging, intercooling, aftercooling, compound compression, valve pressure drop, synchronization, receiver volume, and controls were discussed in these two valuable papers.

MIT's W. M. Rohsenow discussed effects of case and blade cooling on cycle efficiency, and his theoretical results were quite thought-provok-

Incoming ASME President for 1956, Joseph W. Barker; Roy T. Hurley, Chairman and President of Curtiss-Wright Corporation, and D. W. R. Morgan, outgoing ASME President for 1955

Tim Macey of Arthur D. Little Incorporated, winner of the grand prize at POWER ENGINEERING'S "hospitality suite" in the Conrad Hilton Hotel, is congratulated by Editor Andrew W. Kramer

Richard H. Morris, Editorial Director, POWER ENGINEERING, and Lillian Gilbreth, President of Gilbreth Inc. and well-known subject of the book, "Cheaper by the Dozen," talk over Philippine trip on which Mrs. Gilbreth gave an average of one lecture a day for over 30 days to eager, interested audiences

Receiving honorary memberships in ASME, are Simes T. Hoyt, Castle & Cooke, Honolulu; Joseph Armitage of Kearney & Trecker Co.; Clyde Williams, Director of Battelle Institute, Columbus, Ohio; and Philip Spom, President of American Gas & Electric Service Corporation, New York City

"Early Bird" Party at the Glass Hat in the Congress Hotel was given by ladies of the Woman's Auxiliary on Sunday afternoon to welcome first-comers. The party was well attended; members, guests had opportunity to renew friendships

At luncheon for engineers' wives, Ivy Baker Priest, Treasurer of the United States, spoke on "Financial Engineering for Women". Mrs. Karl H. P. Otte, Mrs. Robert H. Bacon, Mrs. Priest, Mrs. Alexander Cowie, and Mrs. C. W. Parsons

R. M. Wingren of Texas Agricultural and Mechanical College, and Paul R. Duffey, of Youngstown Sheet and Tube Company, with Chester R. Earle, the Executive Editor of POWER ENGINEERING

O. S. Woods (left) and Dr. H. E. Crossley (right), of the British Central Electricity Authority, discuss POWER ENGINEERING Handbook power plant training aids with Robt. J. Mitchell, Associate Editor

International note-swapping between Dr. E. H. Crossley, Scientific Advisor to British Electricity Authority, and John R. Michel, General System Engineer for Commonwealth Edison Co., Chicago, Ill.

General Steward E. Reimel (center) was conducting visiting Russian experts Vladimir P. Loukine and Georgi P. Kazanski on a tour of the ASME Diamond Jubilee Celebrations and also the International Automation Exposition by request of the U. S. State Department

The John Fritz Medal, sponsored by ASME, ASCE, AIMME and AIEE being presented to Philip Spom, President of AG & E by Glenn B. Warren (left) of General Electric Company, and Titus G. Le Clair (right), Chairman of the Award Board, for pioneering engineering

Honorary Memberships in ASME went to Simes T. Hoyt; Samuel B. Earle; Joseph B. Armitage; General James H. Doolittle; Carl G. A. Rosen, and Clyde E. Williams. At the meeting they were on panel discussing economic aspects of technology in our past and future

ing. Cooled simple cycle machines can be operated at much higher temperatures, but corresponding increases in pressure ratios are necessary to convert this into a substantial efficiency benefit. The higher pressures offset the size reduction promised by a reduction in specific air flow, and poor design of blades and cooling patterns could similarly offset efficiency gains. Thus, cooling offers mixed blessings and no panaceas.

A very unique paper presented by F. H. Reynst of France brought up the question of pulsating combustion in gas turbines. He suggests that pressure can be upgraded by proper combustion synchronization in properly shaped combustion chambers, thereby getting a larger conversion of thermal energy to mechanical energy. The problem is devising a way of doing this aerodynamically rather than in a rotating "ram-jet" stage, which he says is impractical because of centrifugal forces.

Supercritical Plant

The first supercritical steam plant (Philo Plant), and the turbine for that plant, were discussed in papers by AG & E's S. N. Fiala and GE's Elston and Sheppard, respectively. Steam at 4500 psi, 1150 F with reheats to 1050 and 1000 F make Philo Plant unique, and the engineering approach is also somewhat (necessarily) different. Engineering is reported complete, but construction and testing will continue well into 1956. The heat rate is predicted at 7380 Btu per kwh at one inch Hg exhaust. Steam cooling (at 960 F !) is used throughout the turbine for certain important parts.

Shown here are J. F. Wachunas, Babcock & Wilcox Research Center, C. J. Banwell, Ch. Physicist of New Zealand's Dominion Physical Lab., Sigmund Kopp of Alco Products, and O. P. Bergelin of University of Delaware after session on Heat Transfer in which Banwell spoke on the significance of geothermal power in New Zealand's North Island

R. C. Hagenmiller, Associate Editor, and Richard H. Morris, Editorial Director, POWER ENGINEERING, award attendance prizes at our "hospitality suite". Several hundred engineers found suite handy for renewing friendships, making new ones

Seventy-five prizes, in honor of ASME's 75 years, were donated by POWER ENGINEERING during the course of the Diamond Jubilee meetings

THIS IS THE WAY YOU PULL A GENERATOR ROTOR

This is the tenth article in a series describing the scheduled overhaul of a 25,000 kw turbine generator at U. S. Steel Corp.'s South Works in Chicago. When all the articles have been published the whole series will be reprinted. To reserve copies of the reprint write to the Editor

DIAGRAM IN FIG. 1 shows bearing arrangement for the generator. A is the turbine end, where the generator rotor is supported in a pedestal which is part of the exhaust end of the turbine; B is the exciter end, where the generator rotor is supported in an outboard pedestal that can be moved. The exciter was removed during the operation, so the outboard pedestal could be withdrawn when required.

First step was to support end B of the rotor by means of the crane, and move the bearing pedestal back about 20 ft. Figs. 2 and 3 show the pedestal being moved back, while Fig. 4 shows the steel rods used as rollers for moving the pedestal.

Next operation was to insert between stator and rotor the sheet steel pan shown in Fig. 5. The purpose of the pan was to protect the stator laminations while the rotor was being withdrawn. Before putting the pan in position, a layer of fishpaper was laid on the stator laminations, as shown in Fig. 6, to serve as protection between pan and laminations. Figs. 7 and 8 show the pan being placed in position on the fishpaper.

The bearing pedestal was then rolled back into its normal position and the rotor was lowered on to it, thus freeing the crane for work at the other end of the unit.

At the turbine end of the rotor, i.e. at end A in Fig. 1, the weight of the rotor was then taken by the crane, and the bearing housing was removed. Figure 9 shows this stage of the operation. At the same time a special bracket (Fig. 10) was fitted to the rotor body, as shown in Fig. 11, a view of the rotor taken at a later stage of the operation. The arrows

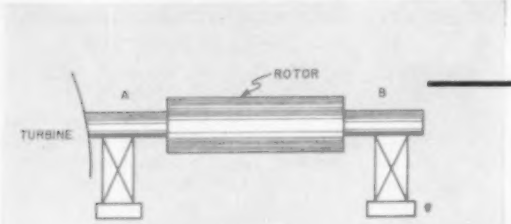


Fig. 1. Diagram to help text explanation. A represents turbine end bearing. B. Exciter end

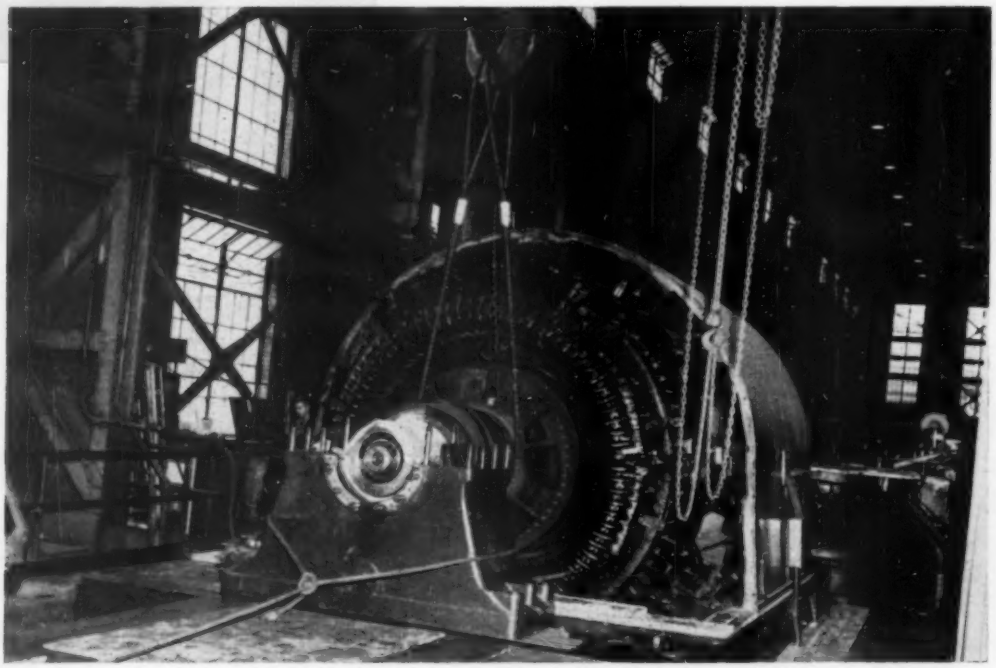
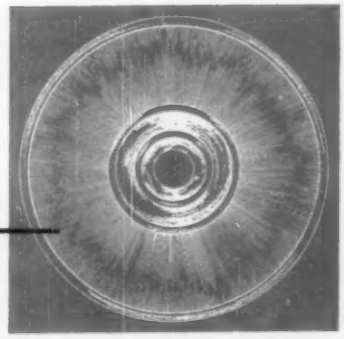


Fig. 2. Start of operation. Turbine end of rotor rests in its bearing. Weight of exciter end taken by crane while pedestal is moved on rollers away from generator

in Figs. 10 and 11 point to the two rollers which roll on the sheet steel pan protecting the stator laminations while the rotor is being removed.

Then the rotor withdrawal began. With one end supported by the crane and the other end resting in its bearing pedestal, the rotor was moved in the direction of the exciter end B until the crane sling was almost touching the stator windings, as shown in Fig. 12. By this time the rollers on the special bracket were over the steel pan resting on the stator laminations, and so the rotor could be lowered by means of the crane to allow the rollers to rest on the pan, and then the crane sling could be removed.

Next month we will describe how the rotor was removed.



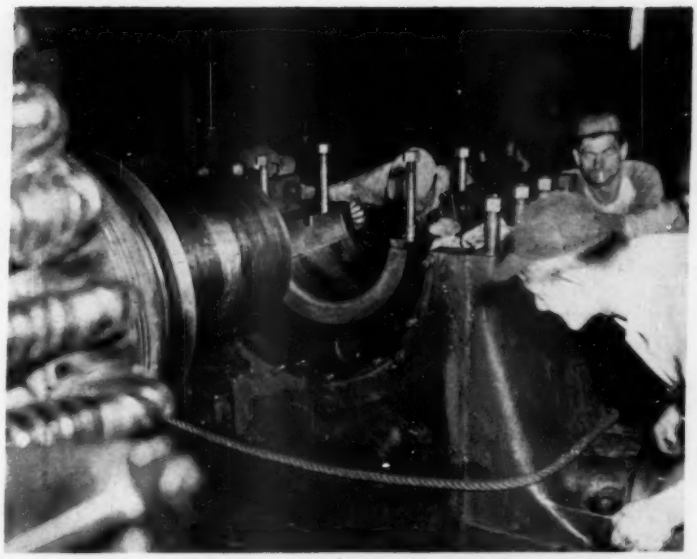


Fig. 3. Above. Moving bearing pedestal (B in Fig. 1) away from generator so sheet steel pan can be inserted

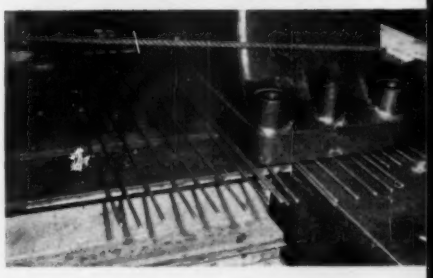


Fig. 4. Right. Steel rods used as rollers for moving bearing pedestal away from machine

Fig. 5. Below. Preparing to insert sheet steel pan between rotor and stator. Wire slings are welded to each end of the pan to make adjustments easier

When all these articles have been published the series will be reprinted. Here are some ways the reprints can be used:

1. To train young engineers.

2. To brief new men before an overhaul.

3. To show management why overhauls need so much time.

4. To illustrate parts when discussing any turbine problem.

If you want one or more reprints write to the Editor.

Fig. 6. Above. Before pan was placed in position, a sheet of fishpaper was laid on the stator to serve as protection between pan and stator laminations

Fig. 7. Above. Threading sheet metal pan between rotor and stator. During this operation weight of the exciter end of the rotor was taken by the crane

Fig. 9. Once the pan was in place, the bearing pedestal was returned to its normal position and the rotor was lowered on to it. The crane was then used to support the weight of the turbine end of the rotor (A in Fig. 1) as shown above

Fig. 8. Above. Pan almost in position. The pan is shaped to have the same radius as the internal curve of the stator

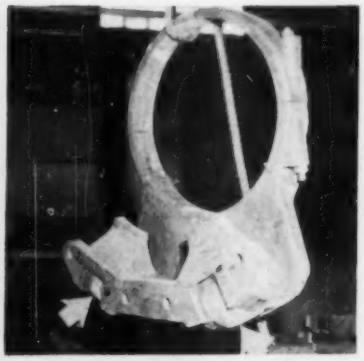


Fig. 10. Above. Special bracket fitted to rotor to enable it to be withdrawn from stator. Arrows point to rollers

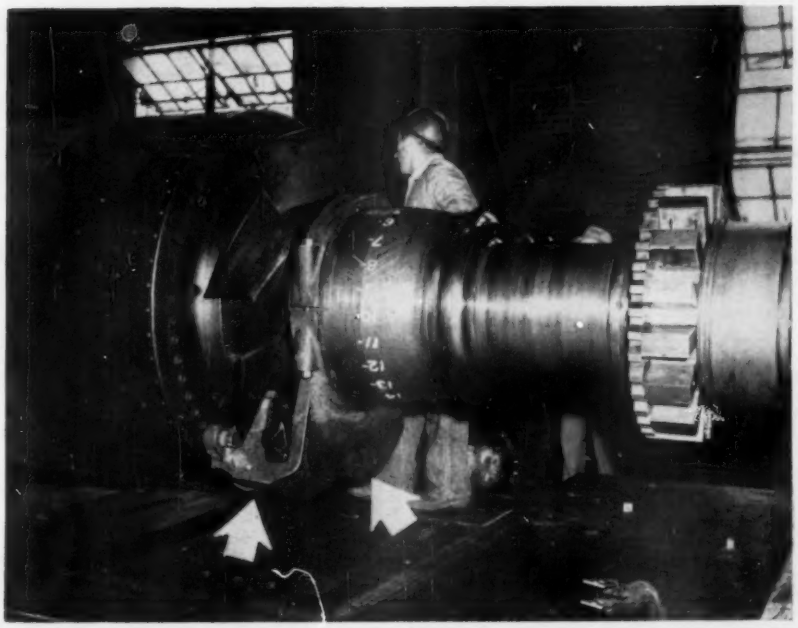


Fig. 11. Right. Special bracket (shown alone in Fig. 10) in position on rotor. Arrows show rollers projecting below bottom of rotor. This photo was taken at a later stage of the operation, but it shows clearly position of bracket

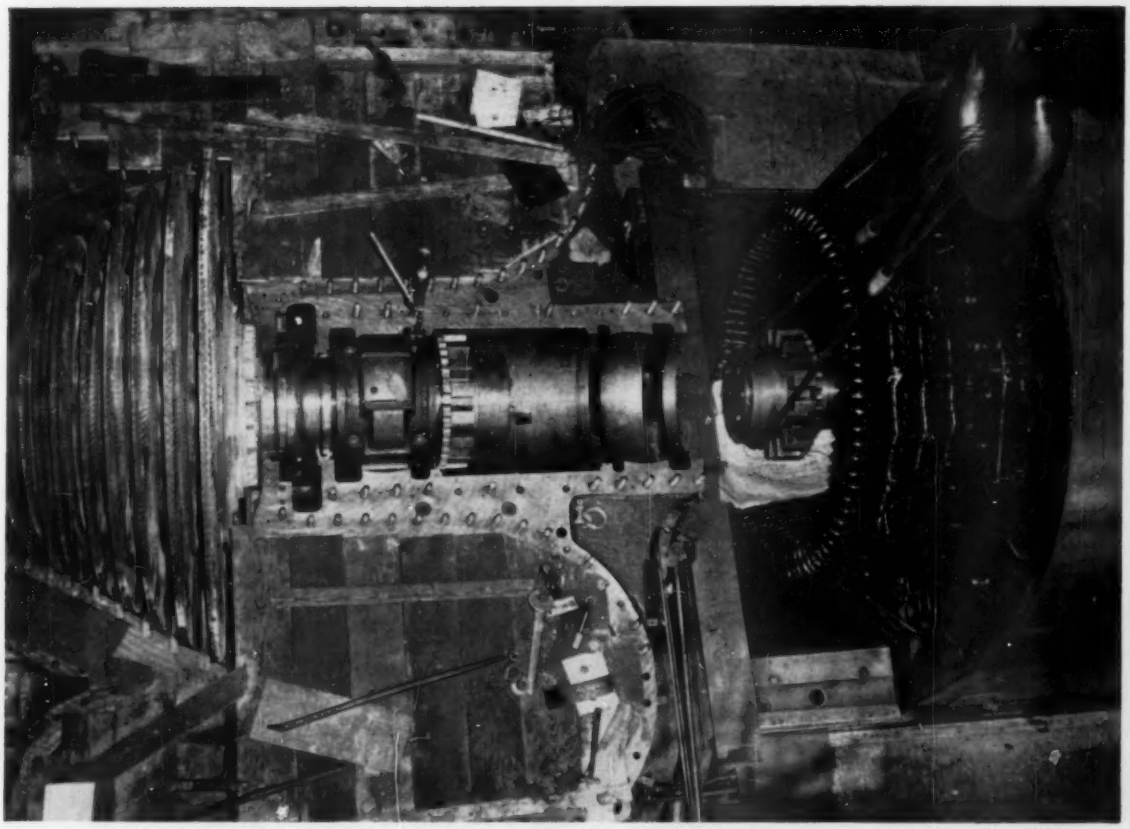


Fig. 12. With the exciter end of the rotor resting in its bearing, and the turbine end held by the crane, the rotor was moved axially until the crane sling reached the stator winding as shown above. Rest of the operation will be shown next month

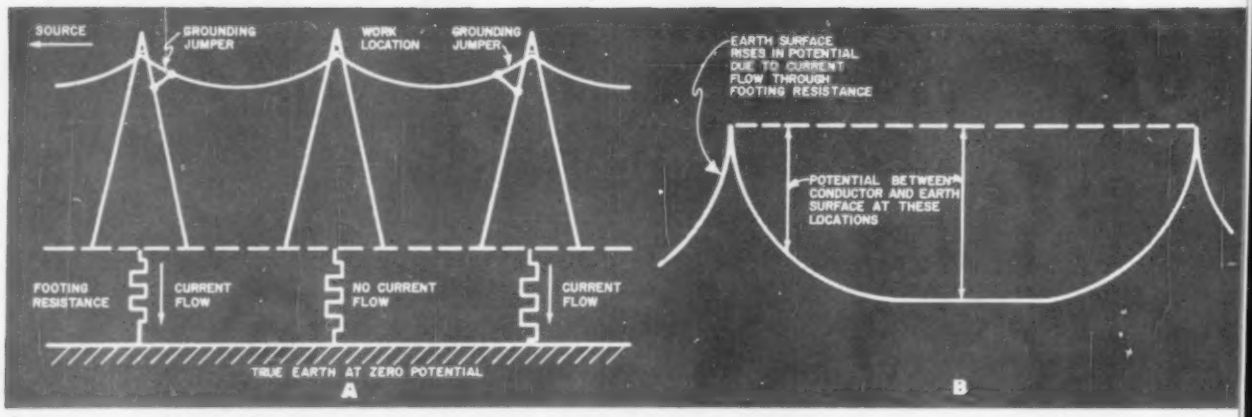


Fig. 1. Shows the danger of assuming that working between grounds is necessarily safe. Diagram (a) shows grounds on either side of tower 2, while diagram (b) shows how footing resistances can cause a dangerous potential at tower #2

Place Portable Grounds to Protect

Most people think a man is safe if he grounds the line on both sides of a job. The authors explain why this is a dangerous misconception and they also show how grounds should be placed to ensure safety

By E. J. HARRINGTON* and T. M. C. MARTIN†

MOST ELECTRICAL utility engineers know something about the work of linemen. They couldn't be utility employees without some understanding of what linemen are required to do in carrying out their daily tasks. They know, for example, that when linemen are called upon to work circuits "hot" they protect themselves by various means to keep them from touching energized apparatus with any part of their bodies. In performing their work under such circumstances they utilize many ingenious pieces of insulating equipment. Rubber gloves, blankets, hoods, etc. are used when the voltages are relatively low; and specially treated wood and other higher dielectric strength materials are used for voltages up to the highest encountered in utility practice. These hot line tools have become increasingly efficient and their use is gaining in favor with linemen and operating officials nearly everywhere in this country.

It must not be forgotten, however, that not all maintenance can or should be done "hot". To begin with, some jobs become too complicated to attempt energized, and even the best hot line tools have their limitations. While it may not be fair to characterize the use of hot sticks as like trying to work with one hand tied behind you and a boxing glove on the free hand, it is nevertheless true that man has not yet improved upon nature in the design of the human hand. Working cold or de-energized still remains the best way in which linemen can bring their own two hands to bear on their problems in many, many cases.

Working de-energized brings up the problem of protection. This is generally provided by some sort of clearance procedure to prevent the circuit being energized while work is going on, plus the placement by the workmen of portable ground sets to make sure (they hope) that failing all else they will establish their own protection. For the "clearance", the lineman depends on others. This procedure varies somewhat between utilities; but in general, it constitutes a sort of contract entered into between linemen and operators and/or dispatchers whereby the former are assured by the latter that a given line section will be isolated from all normal sources of supply including possible back feeds; that this isolation will be accomplished by air break disconnects (ruling out all automatic mechanisms such as circuit breakers, etc.) which can be locked open; that all available ground switches applicable to the section in question will be closed; that "hold" tags will be placed on all isolating devices involved; that, finally, the integrity of this isolation will be maintained until released by the persons to whom the clearance was originally issued. (A good example of clearance procedure was described in "Safety Tagging Works Well for West. Penn.," POWER ENGINEERING, May 1953.)

Linemen obviously require this clearance before they can even start their work. They are not content, however, with this degree of protection. In the first place, there are ways in which their isolated section may become energized without their clearance being broken. Accidental contact with other utility lines crossing over or under the lines being worked can cause such energization. Secondly, the chance of error on the part of their own fellow employees either through mistaken issuance or execution of switching orders, remote though it probably is, could easily result fatally. For the above reasons, and others, the custom has long existed of linemen placing portable ground sets in some way calculated to make them independent of the protection of fellow employees and to some extent immune from accidents.

Returning once more to our original theme, we believe engineers are aware of this placing of portable ground sets by linemen. But now we must say we don't believe engineers have always and universally followed through with this awareness to the point of adequate understanding. And this is surely a prime illustration of where "a little knowledge is a dangerous thing!"

Suppose we try to understand what has been going on by considering brief excerpts from the official safety codes for electrical workers which many States and operating companies have been employing for years to govern the placement of such portable ground sets. A few typical excerpts follow:

(Form A) "All work on de-energized circuits rated above 4,000 volts

*Branch of System Engineering, Bonneville Power Administration; †Safety Section, Bonneville Power Administration

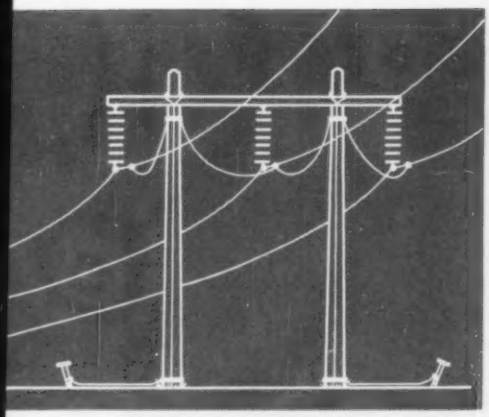


Fig. 2. One method of grounding H-frame wood pole. Details in the text

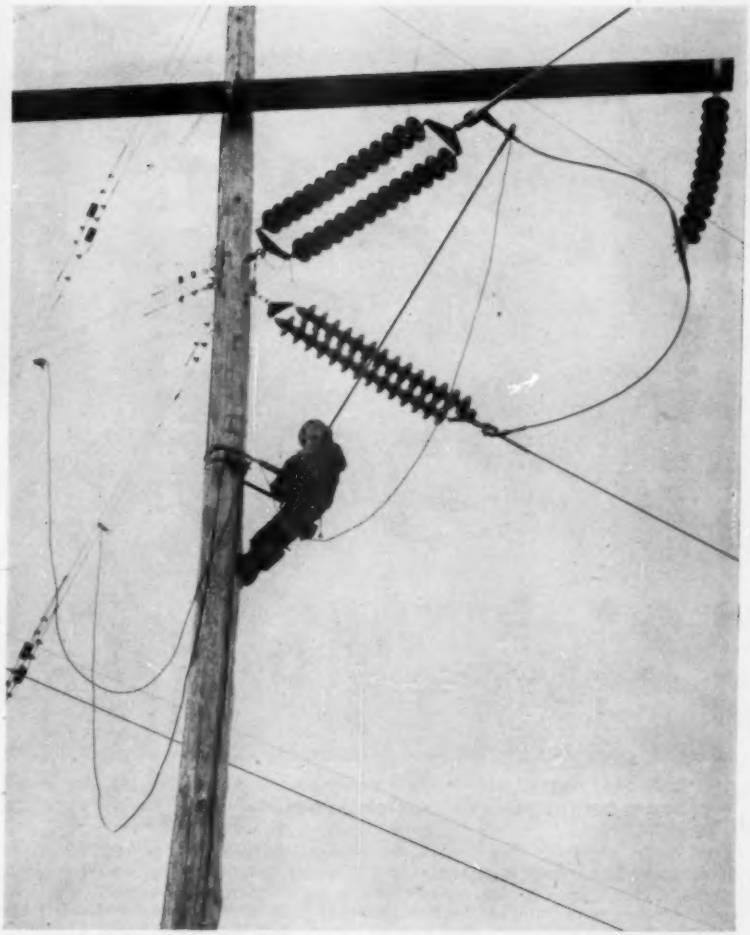


Fig. 3. Method shown in Fig. 2 for one phase of a 230 kv wood pole structure showing ground connections between some of the guy wires and the cluster block

Linemen

shall be done between two sets of grounds. One set shall be placed on the first pole or structure towards the source of energy and the other on the first pole or structure towards the loads."

(Form B) "Transmission line grounds shall be placed at towers or structures adjacent to those upon which work is to be done."

(Form C) "Grounds should not be placed on the same pole or tower on which work is to be done, for in moving the conductor about, the ground might become detached. There may be an exception here if the foreman sees fit. The ground connections should be made at least one span away, usually, and never over a mile from the point of work."

(Form D) "Grounds shall be placed on both sides of the section of line on which work is to be done."

Exception: "On steel tower lines it may be more desirable to install the ground at the tower to be worked on."

A review of company practices confirms the fact that the philosophy which has seemed to surround much of this subject has been to "work between grounds". That many electrical engineers have so long and so uncritically accepted this highly illusory principle is a little hard to explain. In a substation, of course, where an adequate ground mat permits the principle of working between grounds, there can be no criticism of the method. For most transmission line maintenance, however, portable ground sets placed on two adjacent towers or any two towers removed from the tower where the workmen are contacting the line are utterly worthless as protection to linemen and are economically wasteful.

In the absence of a ground mat, what has been lost sight of is the fact that working between grounds is no solution unless the two grounds are the same, and the same as the ground at the structure where the workmen are located. Figure 1 illustrates what takes place where grounds are not true grounds, but incorporate certain amounts of resistance. Consider what happens if the line becomes energized either through switching error or from accidental contacts. The points of grounding plus the conductor then rise above zero potential by an amount equal to the IZ drop across the footing impedance. For all practical purposes, this is the IR drop since very little reactance is associated therewith. Since the work location tower is not purposely connected to the line, no current passes through its footing resistance and it consequently remains at zero potential. It is evident that the workman seeking protection by grounding adjacent towers has climbed into a booby trap, for now the tower which he is on is at true earth potential, but the conductor he is touching has bounced to some completely untenable potential so far as his blood vessels, heart and nervous system are concerned. How high can these voltages become? How low footing resistances do you have, and what fault currents do you experience? In many cases nowadays, fault currents of 10,000 amp are common. When footing resistances of 10 ohms are likewise frequently encountered, it can be seen that potentials of 100 kv are by no means impossible.

Someone will say — "So What! — we don't rely on grounds anyway. We short all three phases and depend on relay operation to save the workman!" First of all, let us hasten to agree that all grounding should always include three phase shorting. This is an absolutely essential requirement of grounding; and in modern transmission line practice this will usually result in minimum ground current flow time during faults. Let us never forget, however, that our man out there is flesh and blood and delicate organic cells that cannot stand even a small part of

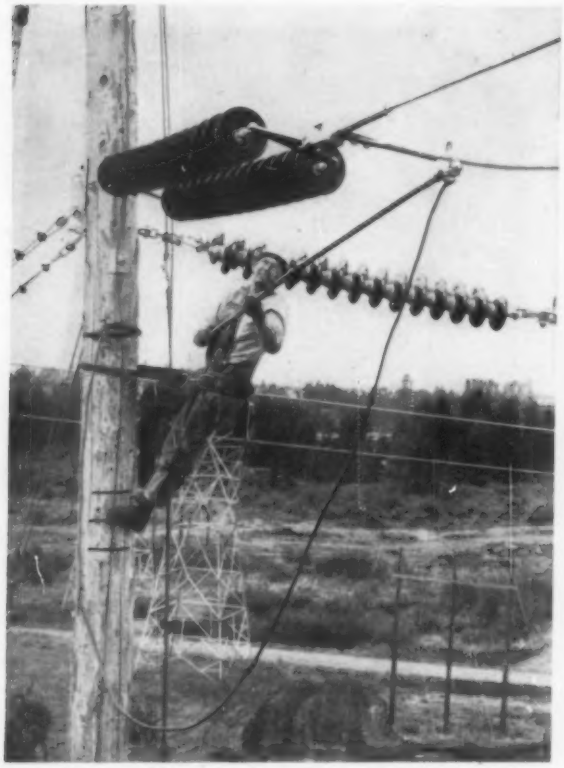


Fig. 4. Another view of pole in Fig 3 showing bare copper wire running down pole from the bond holding the cluster block

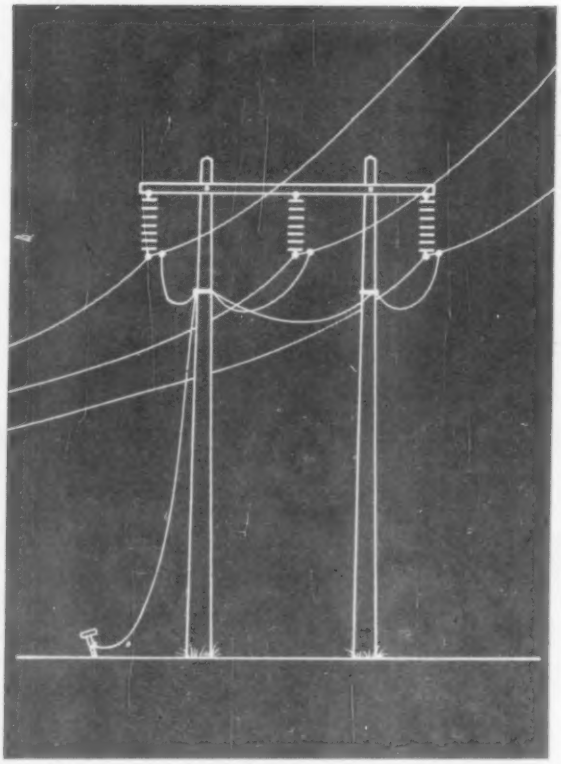


Fig. 5. Most recently advocated method. Grounded "potential bands" are placed around pole about 10 ft below conductors

one cycle of really high potential difference across his points of contact. And likewise let us remember also that ground current will flow unless all three phases of our breaker open (interrupt) simultaneously. How much reliance should we put on synchronized opening and how much allowance should we make for non-sequential operation of three phase breakers? It should also be remembered that this time limitation of the duration of ground current flow applies only to three phase shorting. Where the accidental energization consists in but a single phase contact with a foreign utility line, no comparable limitation of ground current flow time exists.

A return to first principles would seem to be in order. There is nothing per se desirable about working between grounds. What is sought is a means of creating a zone of constant potential around a workman so that there is absolutely no potential difference between what he is standing on or embracing with his body and what he is touching with his hands. If working between grounds achieves this end, it is a proper means. If it does not, it is worse than useless and should be abandoned forthwith.

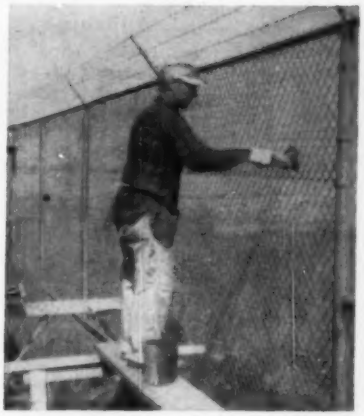
On steel towers, the problem is relatively simple. Shorting all three conductors and connecting them to the steel at the work location will create an effective equipotential zone for the linemen at that tower. There are some necessary precautions to be taken, however. Shorts and grounds must be securely attached in a manner that during normal work processes they will not become disturbed. At dead-end towers or whenever a conductor is to be opened, both sides of the opened circuit must be securely shorted and grounded.

A more difficult problem is presented by wood pole lines. The authors have made some suggestions regarding this problem and its practical solution. In essence, the proposal is to turn wood poles into members that electrically simulate the properties of steel towers. This can be accomplished by fastening a bare wire to the pole in such a way that the entire length of the pole within working range is paralleled and grounded. In practice, this bare wire would probably be of the stranded type and would be looped around the pole above a cross arm and brought down along the pole to the ground line. Two chain bands with associated cluster blocks would be cinched to the pole, one at the ground line and the other somewhat below the level of the conductors. The flexible wire mentioned above would be securely fastened under these bands. The cluster block at the top band would be used to receive three grounding leads which would be attached to the de-energized line conductors by means of hot sticks while the lower cluster block would serve as attachment for a lead going to a suitable driven or auger type ground rod. It would be necessary in using this method of protection to attach all guys (at points below their insulators, if any) to the wire dropped down the pole. The method is shown in Fig. 2.

This proposal has met with some dissent on the part of linemen that merits consideration. It is not thought to be safe practice to rig bare stranded wire along the upper portions of wood poles prior to de-energization. It would only be safe to carry the rigging of this bare wire up to a point perhaps 10 feet below the conductor level until the outage is taken. Since the holding of outage time to a minimum is always desirable and sometimes a prime consideration in determining whether to work "hot" or "cold," it would be desirable to devise a method that permits as much preparation as possible to be accomplished prior to de-energization.

Another and perhaps better method of handling wood pole work would be to forget about trying to turn the wood pole into a metallic tower member and simply place a so-called "potential band" around the pole about 10 feet below the level of the conductors. This band would be of the chain binder variety incorporating a suitable cluster block. This band could be rigged anytime and suitable grounding accomplished either to an available *continued on page 115*

5 Ways to Paint a Link Chain Fence — Pro and Con of Each



1. Hand Brush. (Left)

Equipment: Standard oval or flat 4 in. paint brush.
Method: Usually requires two men, one on each side of fence.
Pro: Requires little equipment.
Con: Slow, tedious, eye-tiring.

2. Portable spray gun. (Right)

Equipment: Portable compressor and portable spray gun. Some pieces of plywood for baffles.

Method: Plywood is usually hung on fence with drip pans at bottom to catch excess paint. Fence sprayed one side at a time. Usually one man sprays while another prepares the paint and moves baffles along the fence. For fast work a third man is necessary to help thinning and mixing paint and moving equipment.

Pro: Does thorough job quickly.

Con: Equipment is expensive. Nearby objects need protection.

3. Roller Coating. (Left)

Equipment: Deep napped lamb's wool roller.

Method: One man uses roller very wet with paint to allow it to flow in between interstices of wire mesh. Man on opposite side of fence uses his roller comparatively dry to pick up runs, sags, etc. Third man usually employed to follow with brush or spray to paint pipes and parts of fence too close to pipes for roller to reach.

Pro: Little equipment needed. Faster than hand brush.

Con: Still rather slow. Rollers wear out quickly.

4. Flo-Coating. (Right)

Equipment: Portable pump. Trays for catching paint. Pieces of plywood.

Method: Paint is poured on top of fence and allowed to run down the mesh. Paint collects in pans under the fence from which it is repumped to the top of the fence for the next section. The plywood baffles are used to prevent splashing.

Pro: Very thorough job.

Con: In addition to the expense of equipment, it must be possible to excavate underneath the fence to accommodate the trays.

5. Broom Painting. (Left)

Equipment: A 12 to 14 in. push broom with medium to soft bristles with a 5 to 6 ft handle. Window washing brooms or automotive washing brooms are best as they do not matt down with paint and last longer than others. Also rectangular pan such as a baker's pan, approx. 15 in. by 24 in. by 6 in. deep with a wiping rod about 6 in. from one end.

Method: Paint is applied fairly dry and brush strokes should run with the mesh of the fence. Usually done with one man on either side of the fence. Handle may be unscrewed and head of broom used alone for posts and pipes.

Pro: Cheapest, easiest, and quickest method.

Figs. 1, 2, and 3 courtesy Subox, Inc.; Figs 4 and 5, James B. Sipe and Company

How Much Does a Ton of Coal Weigh?

So far as we know, a ton of coal still weighs exactly 2000 lb in the U. S., but the author wishes to emphasize that a 50-ton car, capacity loaded, may not contain precisely 50 tons of coal. Since coal weights are important, here are ways to estimate

By **FRED M. REITER** • Fuel Engineer, The Dayton Power & Light Co.

THERE ARE MANY problems in which the weight characteristics of coals are significant. Frequently, the amount of coal that a car, bin, bunker, compartment or other container will hold becomes important.

The kind and source of the original solid coal under consideration affects the weight of the coal. There is a variation in the specific gravities or densities of coals from different seams or areas. Commercial washers of coals from a number of sources discover this very quickly in the settings or media densities required in the preparation of coal. The density of the shale or rock that comes to the preparation plant with the coal affects operations materially.

For purposes of illustration, Table I lists the specific gravities of some of the more common West Virginia coals. The variation from 1.234 to 1.336 exceeds 8 per cent. The following tabulation lists the approximate specific gravities of the major components of the coal as it may come from the mines to their preparation plants [1, 2]:

Component	Range of Specific Gravities
Lignite	0.5 to 1.30
Pure coal, without any impurities	1.05 " 1.15
Bituminous coals, general average	1.15 " 1.50
Anthracite coals, " "	1.27 " 1.70
Clay	1.50 " 1.90
Shale	2.20 " 2.50
Slate	2.25 " 2.80
Pyrites	3.20 " 3.60
Straight pyrites	5.00 " 5.20

1 Coal Manual for Industry, A. W. Williams, p. 34
2 Coal Preparation Manual, McNally-Pittsburgh Mfg. Co.

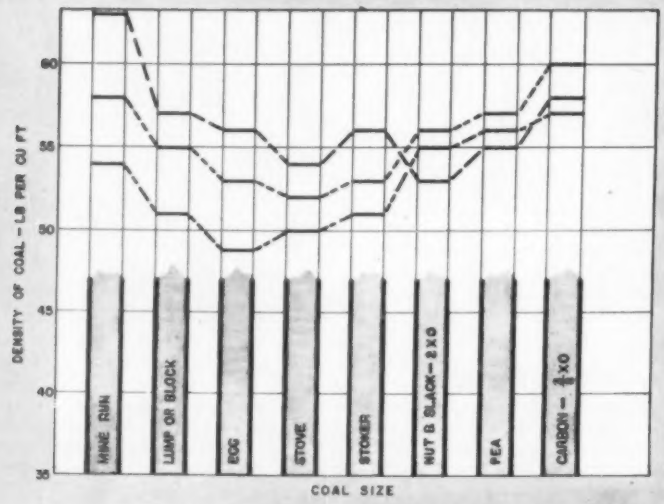


Fig. 1. Chart shows relation between size of coal and density, lb / cu ft

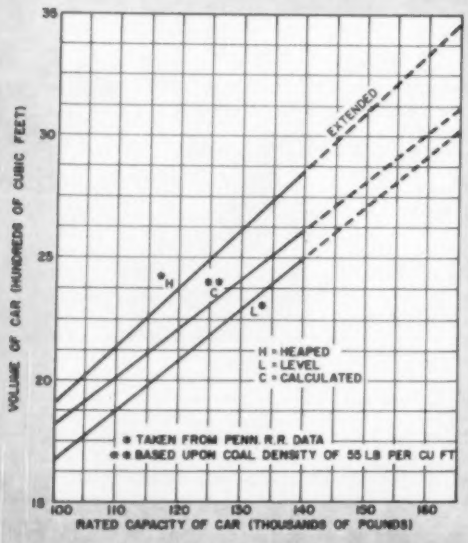


Fig. 2. Volume vs capacity of railroad coal cars

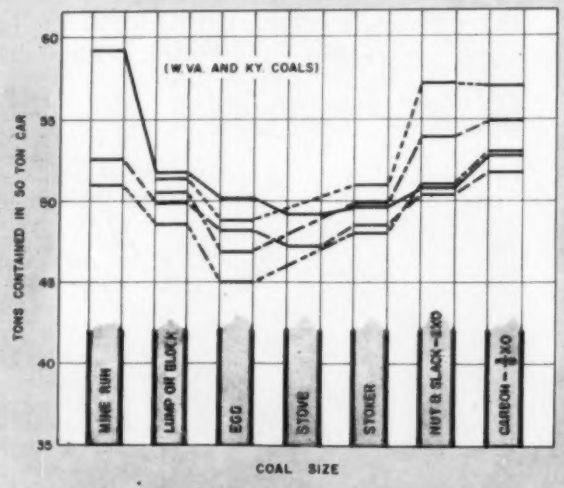


Fig. 3. Size vs weight of coal contained in a 50-ton car

The specific gravities are important measurements to the coal preparation operator. He must float his coal on the volume of water or solution used in the cleaning of the raw coal. The "density" in pounds per cu ft is a simpler and more valuable term or measurement to the power plant operator. The chief practical difference between the specific gravities and densities of materials is that the specific gravity refers to the solids of the material. Pieces of coal with specific gravities of 1.15 to 1.70 (for bituminous and anthracite coal), would and do sink in water whose specific gravity is 1.00. A cubic foot of these same coals, in loose form, would weigh less than water, and would float if placed in water as bulk in a weightless container. The voids are included in the cubic-foot measure.

The densities of the more common materials used in connection with the coal handling operations of a power plant are listed as follows[2]:

Material	Density lb per cu ft
Water, normal temperatures	62.5
Coal, anthracite, loose, broken sizes	52 to 56
" bituminous, " " "	47 to 56
" stored and compacted	55 to 70
Cement, loose	56
Concrete, average	150
Wood, average	25 to 50
Ice "	56 to 62
Iron "	450
Shale, black	162
" in loose pile	92

The specific gravities of the various West Virginia coals after immersion in water for 10 days are included in Table I as confirmation of the later discussion of the effect of moisture on the increase in the specific gravities or weights of coal.

The size of the coal loaded is an important determinant of the weight of the coal. The basic densities of the various coals discussed in section 1 of this article may not be nearly as important in the final weight of a given volume of coal as the size of the pieces of solid coal, the air spaces between the lumps or particles, or the percentage of fines mixed with the larger or top sizes of the coal. The voids may offset the differences in the natural specific gravities of the coals.

Figure 1 lists some average weights of various sizes of several coals in terms of lb per cubic foot, based upon volume measurements of uncompacted coals in the more common sizes. Figure 2 gives the approximate volume of various sizes of ratings of railroad freight hopper coal cars from 50 to 90 tons capacity, on the basis of 55 lb per cu ft for all coal loaded, without regard for source or type. This is for estimating purposes only, since calculations from actual drawings might be more accurate. However, calculations from drawings would not conform to actual loading practices at the mine or loading tipples, where top contours must fit shipping experiences, wind conditions, spillage, and so on.

Figure 3 shows some actual weights of cars of different sizes, averaged from shipments of various sources of bituminous coals of West Virginia and eastern Kentucky. These figures are subject to considerable variation within any given sizes, beyond the differences in natural density, moisture and ash content, and other factors within the coals themselves.

Different areas have various dimensions for each nominal size of coal. The Anthracite Coal Committee of Pennsylvania adopted 10 size specifications; from "broken", 4⅜ by 3 in., to "buckwheat", ⅜" by 0 in.[1] The accepted sizes for the bituminous field are not so closely defined. The normal range of sizing for the common standard nomenclature or nominally quoted sizes might be:

Mine run	All coal as loaded in mine cars or belt—all sizes
Lump or block	5-in. to 12-in. cubes (approx.)
Egg	5-in. by 2-in. or 3-in.
Stove (anthracite)	2⅞-in. by 1⅝-in.
Stoker	2-in. to 1-in. by ⅜-in. or ¼-in.
Nut and slack	2-in. to 1-in. (sometimes ¾-in.) by 0
Carbon	⅜-in. to ⅛-in. by 0

Dimensions below 5-in., indicated above, are screen sizes used in the separation of the various size gradations. Figure 1 shows a pea size, smaller than nut and slack, that will pass through a 13/16-in. screen but is retained on a 9/16-in. screen. This is an anthracite coal sizing. The term "double-screened" refers to coal that has passed through one screen but was retained on the next smaller or another screen, as indicated by the sizes from egg to stoker in the above tabulation. "Resultant" coal is the total portion that has passed through a specified screen, for example, the 2-in. by 0 nut and slack, or ⅜-in. by 0 carbon. "Modified" coals are special mixtures, such as carbon sizes returned and mixed with a larger double-screened size, thus increasing proportionately the percentage of fines. "Doughnut" coals are the in-

Table I. Specific gravities of solid coal from some West Virginia seams, both air-dried and after 10-day water immersion. Average quantity tested, 20 pounds[3]

Name of Seam	Specific Gravity	
	Air-dry	After 10 days in water
Sewell	1.234	1.290
Douglas (Red Ash)	1.246	1.300
Beckley	1.253	1.310
Powellton	1.257	1.295
Island Creek	1.261	1.300
Winifrede	1.262	1.298
No. 2 Gas	1.268	1.291
Chilton	1.272	1.303
Hernshaw	1.273	1.302
Eagle	1.277	1.310
Pittsburgh	1.278	1.312
Alma	1.280	1.311
No. 5 Block	1.291	1.315
Pittsburgh No. 8	1.295	1.327
Pocahontas No. 3	1.297	1.364
Pocahontas No. 5	1.298	1.366
Sewickley	1.307	1.341
Freeport	1.307	1.339
Redstone	1.309	1.340
Pocahontas No. 4	1.324	1.364
Coalburg	1.336	1.380

[3] Data from Some Physical Characteristics of West Virginia Coals, by C. E. Lawall and C. T. Holland, West Virginia University. New York meeting, AIMME, February, 1932

Table II. Some samples of moisture weight allowances on washed coal which has been treated on dewatering screens only, or for coal that has been water dedusted

Coal Size When Washed	Through Mesh or Round Perforations	Over Mesh or Round Perforations Not Larger Than:	Deduction for Moisture on Washed Coal (Per Cent)
Stove	2 in.	1¼ in.	1½
Nut	1½ in.	¾ in.	1½
Pea	1 in.	⅜ in.	2
Stoker	1½ in.	⅜ in.	2½
Carbon or Duff	⅜ in.	——	7

Table III. Effect of coal sizes on weight of two 50-ton cars loaded with egg and carbon-size coal. Both cars filled to capacity with coal from same source

Conditions	Egg Size	Carbon Size	Difference (Per Cent)
Loading weights (Fig. 3 average)	47.5 tons	54 tons	13.7
Ash (per cent)	5	10	
Gross weight (Fig. 3) with added ash	49.4 tons	58.4 tons	18.2
Moisture (per cent)	2	10	
Gross weight (Fig. 5) with added moisture	50.4 tons	64.2 tons	27.4

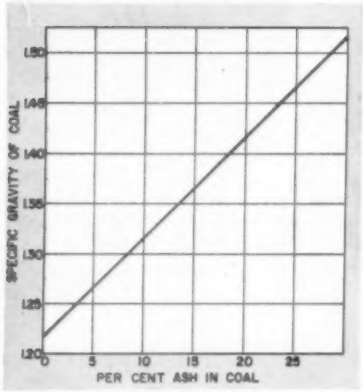


Fig. 4. Percentage of ash in fine coal will have very great effect on weight

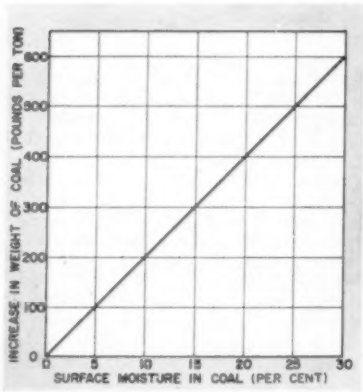


Fig. 5. Graph shows how much water can be bought at coal prices if coal is wet.

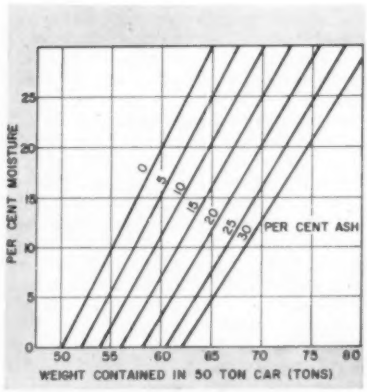


Fig. 6. How percentage of moisture and ash combined affect weight of 50-ton car

termediate sizes between full sizes to zero; an example is the stoker size of 1-in. by ¼-in., which is extracted from the complete 3-in. by 0 size. The center section has been taken out, like the hole of the doughnut.

Sized coal avoids segregation. In a shipment of coal that consists of relatively large pieces mixed together with fines, large sizes frequently become concentrated in one zone. This affects the weight distribution of the coal and an unevenness in all the succeeding operations. It is evident that with such a wide variation in the final sizing of bituminous coals, the size consist, or the percentage of each screen size contained in the whole, unless strictly specified and maintained by good preparation plant control, varies widely. As will be discussed later, this affects the moisture and ash content, which in turn alter the weight characteristics of the given coal.

Weight Affected by Loading

Individual mine loading practices or state or ICC regulations may affect the weights of rail cars, trucks, or any common or private carriers. The weight of a car of lump or block coal may be unnaturally higher than the densities or normal volumes would indicate, because these large blocks can be stacked around the inside top of the cars, and the inner top cone of coal may be higher than normal for other sizes. The large size and stability of these large blocks diminishes the danger of rolling off the car tops. Small carbon-sized coal cannot be loaded high because of loss due to wind blowing and washing by rain.

Next to the calculated volume of coal cars (curve C of Figure 2) are plotted the actual volumes of standard self-clearing steel hopper cars for level full (curve L) and heaped (curve H) taken from the coal car equipment section of the Pennsylvania Railroad Directory of Anthracite and Bituminous Coal Mines (June 1, 1945). These curves are included in order to show the variation that can occur in loading, from below level, as would be the case of carbon or very fine coals, to the extreme of heaping or stacking large blocks. The calculated volume curve, A, based upon an average constant weight loading of 55 lb. per cu ft, falls between the standard measured volume limits for level and heap loading.

An examination of the size-weight curves portrays some of the variations due to loading practices. Egg coal provides the lightest loading weights because of natural loading (without stacking or blowing), and a high percentage of voids for this larger size. Its uniform sizing gives practically no segregation. This size will settle or shake down in transit. The nut-and-slack and the carbon sizes show the greatest variation within their respective sizes. They generally prove to be the heaviest in loading of all of the prepared sizes, up to 20 per cent greater than the egg or stove sizes. This is due to the percentage of fines, down to 0, which they contain. These fines can become quite heavy if their ash and moisture content increases greatly, as will be pointed out. This added weight not only shows up in the measured weights of the cars or trucks, but is felt on the consumers' belts and conveying equipment. The loading of wet fine coal must be watched and volumes kept reduced in order that local, state, ICC or plant equipment load limits are not exceeded. This is particularly true of truck hauling, where state patrols are constantly on the watch for overloading.

Ash Content Is Factor

The ash content increases the weight of the coal. A previous tabulation showed the specific gravity of mineral impurities such as ash, slate, pyrites, etc., to have a range of 2.25 to 3.60, compared to 1.15 to 1.50 for average bituminous coal, and 1.05 to 1.15 for pure coal. Ash content of the coal becomes one factor in the variations among coals within the same size groups.

A car of washed coal should weigh less than the raw coal from which it came, moisture content being the same, because of reduced ash percentage. It is this difference in specific gravity between the slate or rock and the coal components of the aggregate coal that makes washing a practical procedure.

Frequently the fines, ⅜ or ¼ by 0, by-pass the washers and are either returned raw to the nut and slack portions or are shipped as raw carbon. These fines are high in ash, hence they are heavier than the cleaner larger sizes. Figure 4 shows the effect of the percentage of ash on the specific gravity of a coal that runs 1.22 for the pure coal. It illustrates what can happen in carbon or fine coal sizes. At 25 per cent ash, its specific gravity rises to 1.47, over 17 per cent heavier than the pure coal.

Moisture Also Important

Moisture, like ash, increases the weight of coal. One per cent of moisture, by weight, adds 20 lb to each net ton of coal. It can be assumed that moisture does not displace coal, but it does act in the following manner:

Moisture gathers in the pores of the coal by absorption. This can be particularly true where the inherent or chemically-combined moisture has been driven off by high drying temperatures. The dried coal then becomes "thirsty" for moisture to fill its chemical shortage.

Moisture coats the surfaces of the coal particles by wetting or by adsorption. Fine coals have large surface areas to be wetted and to gather molecules of moisture in an adsorbed moisture layer.

Moisture is formed by oxidation or weathering, forming chemically-combined or inherent moisture. This coal may feel dry to the hands, but may contain 3 per cent or more moisture, by weight.

Moisture flows into the voids between the pieces or particles because of rain or additions after mining or loading. This water may drain out of the car in time, unless the coal is fine enough *continued on page 117*

What's Being Done to Prevent Another Turbine Failure

At the ASME 1955 Annual Meeting, papers on four recent turbine failure investigations were presented. Here is a summary of the causes and main steps being taken to prevent similar accidents in future

EACH OF THE FAILURES described here was followed by a very thorough investigation to determine causes of failure and what could be done to prevent its happening again. Full reports on the investigations are given in the ASME papers listed at end.* Here we give, for each unit, a brief summary of the probable causes of failure and the main steps proposed for the future.

1. Arizona Rotor. Built for Arizona Public Service Company. 147,000 kva, 3600 rpm. Burst at 3400 rpm during balancing in factory. March 4, 1954.

Causes of failure: Unusual and severe stress concentrations combined with the characteristics of the material from which the rotor was made. The stress concentrations were created by numerous internal cracks in the body of the forging. Alloy segregation, in string-like regions of above-average alloy content, appear to have been the nuclei of the internal cracks formed during manufacture of the forging. The material from which the forging was made was, under certain conditions, susceptible to brittle fracture. This is a problem common to most large forgings for generators and turbines. Materials totally immune to brittle failure, such as austenitic steel or some non-ferrous metals, are available, but their lower strength and other unfavorable characteristics make their use undesirable.

2. Cromby Rotor: In service at Cromby station of Philadelphia Electric Company. 216,000 kva, 3600 rpm. Burst at 3780 rpm on overspeed test. Sept. 27, 1954.

Causes of failure: Similar to the Arizona rotor, except that stress concentrations were created by a row of holes drilled and tapped in the rotor body for the attachment of studs used to repair portions of the teeth damaged when milling the coil slots. The material used for the rotor was similar to that used for the Arizona unit.

Steps to prevent recurrence of above failures: Extensive improvements in the machining of turbine generator rotors have been introduced which should eliminate damage to the rotor teeth. Breakage of cutters is being reduced through improvements in slot and cutter design and greater attention to keeping cutters sharp and tight on the spindle. In the unusual case in which damage does occur, the rotor will be scrapped rather than resorting to repair studs.

Sonic test acceptance levels have been defined more precisely and tightened substantially.**

Sonic test data and records of repairs with studs screwed into the rotor body have been reviewed and evaluated for all rotors. Nine other rotors in which the magnitude of the localized stresses at the repair studs was equal to or of the same order as that in the Cromby rotor have been replaced.

Much work is being done to eliminate the possibility of stress concentrations in the rotor. The largest possible fillets are being made at tooth slots, ventilation slots, balance slots, cross slots, and so on. All closed-end holes, such as balance plug, ventilation and coupon holes drilled in a rotor are now finished with hemispherical ends after drilling. Semicircular fillets are now being employed at the bottom of the first one or two coil slots or subslots adjacent to the poles. Photoelastic tests show that the highest stresses in a rotor of normal cross section exist at these locations and that the semicircular fillets reduce the stress concentration considerably.

Eleven full-size rotor forgings, some generator and some turbine, have been ordered from the four heavy forging producers in this country and one in Germany to evaluate the effect of modifications in composition, melting and pouring practice, and heat treatment on soundness, cleanliness, and mechanical properties. Six of these are composition modifications of present standard grades. The others are intended to evaluate the benefits of duplex melting, vacuum pouring, and several quenching media. One of the forgings has been instrumented to determine cooling rates throughout the body of the forging when quenching in air, oil, and water.

In addition to these improvements, forging specifications are being revised to include requirements for higher tensile ductility and Charpy impact strength; provisions for additional tests to determine transition data, hydrogen content, segregation pattern, property uniformity, and continued refinement of the ultrasonic inspection techniques and tightening of the acceptance limits.

3. Tanners Creek. In service at the Tanners Creek station of the Indiana and Michigan Electric Company. 125,000 kva, 1800 rpm 1-p spindle. Large segment broke out of the first stage wheel of the intermediate-pressure turbine section. January 1953.

Probable causes of failure: Combination of residual stresses which were not removed by the tempering and stress-relief heat treatments, an unusually low long-time high-temperature ductility, and thermal stressing of the first-stage wheel due to admission into the first-stage wheel space of wet steam from the steam-seal regulator piping.

Steps to prevent recurrence: Residual stresses are now measured on all rotor forgings prior to machining; a modified heat treatment has been introduced to give better long-time high-temperature ductility, although at some sacrifice in high-temperature strength; and the piping of steam-seal regulators has been modified to minimize the possibility of wet steam thermally stressing the rotor wheels.

4. Ridgeland. In service at the Ridgeland station of Commonwealth Edison Co. 165,000 kw, 1800 rpm. 1-p spindle. Spindle burst during a routine overspeed test. Dec. 19, 1954.

Causes of failure: A combination of hydrogen flakes and high notch sensitivity (susceptible to brittle failure) occurring together in areas deep within the central mass of the forging was the primary cause of the fracture. It is unlikely that either of these conditions occurring by itself could have resulted in a failure.

Steps to prevent recurrence: Four other turbines with 1-p spindles using the same type of forging as the Ridgeland unit had been built. After the Ridgeland accident three of these units were dismantled and thoroughly sonically retested. One was found to warrant replacement. It was not felt necessary to dismantle the fourth unit, since a re-examination of the original test records showed the forging to be unquestionably sound. Subsequently, test records on all spindles produced since sonic testing was introduced were examined carefully for any signs that might call for further investigation.

As in the above examples, development is proceeding in the three likely areas where improvement in the metallurgy of large forgings can take place: improvement of the forging material, improvement in forging processing *continued on page 118*

Fig. 1. Planning is the essence of Atlantic Refining's power maintenance program

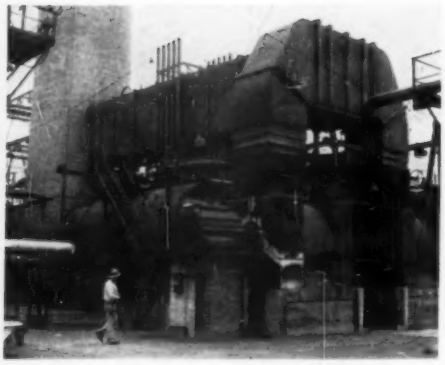


Fig. 2. Waste heat recovery from still

Power Department of Atlantic Refining Co. Gets Efficiency Through Organization

Management and control of power production and maintenance can be complicated, particularly in the chemical and process industries. Atlantic's efficient procedure planning reduces cost and confusion

By W. A. SHMIDHEISER *

THE SCOPE OF a power department's functions is as narrow or as broad as are the operations of the plant it serves. In most instances, the range of power services is limited, clearly defined, and uncomplicated; in the chemical and process fields, however, the power department's functions are quite the reverse. In these industries, the power department of the plant must be all things to all men. It must supply, usually, large quantities of electricity, steam, gas, oil, air, and water at varying voltages, pressures. temperatures, and degrees of purity to widely separated and frequently changing points of use. Furthermore, it must undertake to supply these services with every assurance of dependability since many process operations are critically sensitive to treatment conditions during the period of process. Such requirements necessarily imply the need for a high degree of power department organization.

There is no attempt here to establish either a standard or a philosophy of power department organization. The needs and policies of individual plants or companies are too diverse to tolerate the proposal of "rules" for organizing the activities of all power departments — even within the framework of one type of industry.

This article does, however, attempt to show how planned organization has helped our Power Department meet its plantwide service and supply responsibilities. It will be noticed that reference is often made to the report forms we employ. It has been found that use of these forms and data sheets greatly simplifies management and control of our various activities. Very little paper work is involved in this system and much confusion and misdirection are eliminated.

Products Are Varied

The Atlantic Refining Company plant at Philadelphia, Pa., manufactures all kinds of petroleum products, including some petro chemicals. The regular refinery products are various grades of gasoline, burning oils, lubricating oils, greases, heavy fuel oils, and wax. The petro chemicals are detergents, ammonia, etc. The plant covers an area in excess of 600 acres and is situated on the Schuylkill River, with an important highway traffic artery dividing the plant.

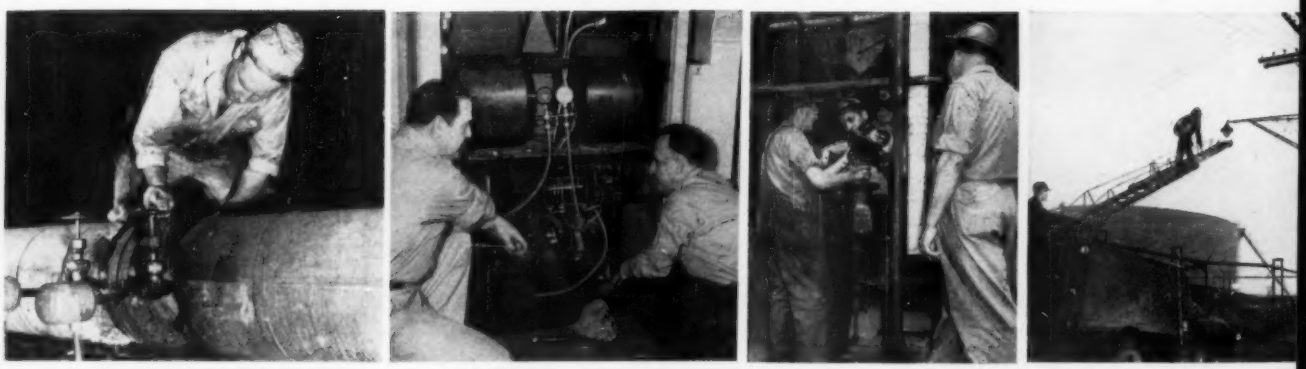
As in all petroleum refineries, large quantities of steam, electrical power, water, fuel (both oil and gas), are required for processing purposes and it is the function of the Power Department to supply all utilities used throughout the manufacturing divisions. The department also handles all electrical maintenance, and, except in case of construction of complete new major units which may be contracted, performs all the electrical construction work, including pole lines, cables, etc. There is a total of 385 men in the department.

Since the functions of the department are so varied, the work has been organized according to the various types of work performed, as indicated by the organization chart shown in Fig. 7.

Electrical Division is responsible for: (a) the maintenance of all electrical equipment, including the 13,200-volt substations handling the incoming lines from the public utility; (b) the construction and installation of electrical equipment throughout the plant; (c) the generation of approximately 11,000 kw in four power houses and the distribution through the various lines and substations of a total of 42,000 kw.

The maintenance group carries a shift electrician in each yard to cover trouble calls from 4:00 P.M. to 8:00 A.M. and over the week-ends and holidays. All electrical troubles are

* Superintendent of Power, Atlantic Refining Co.



Figs. 3, 4, 5, and 6. Typical duties of the Power Dept: pipe-fitting, airconditioners, steam traps, outside electric lighting

reported to a central location, where a simple trouble slip (Fig. 14), is made out, on which is recorded the time, location and nature of difficulty. Workmen are then dispatched to the job and when the trouble has been cleared, the slip is signed by the attendant at the location in trouble, denoting that someone has attended to the job. It has been found that this means of checking on job orders, although simple to handle, has worked out quite satisfactorily.

Construction Group installs new electrical equipment, including substations and large lighting installations. Since the plant covers so much territory, most of our distribution is by open wire on pole lines, although aerial cable has been installed in some locations. The two line gangs required for pole line construction and maintenance are equipped with line trucks, one of which is equipped with a winch. The use of these trucks has been amply justified.

Power Group handles the generation and distribution of electricity from power houses. Three of these houses, which generate 25-cycle current, are connected by tie lines, while the fourth and newest house generates 60-cycle current and operates in parallel with the public utility company supplying the services.

Of the three houses generating 25-cycle current, one contains four 840-hp diesel engines connected to 550-kw, 2300-v, 3-phase alternators; a second house has two 1000 kw, 2300-v, 3-phase generators driven by 1250-hp back-pressure turbines, and the third house contains a 1500 kw, 440-v, 3-phase generator driven by a 1800-hp condensing turbine. Also located in this house is a 3000 kw frequency changer, which converts 60-cycle current to 25-cycle; the generator is driven by a 4200-hp synchronous motor which takes power from the public utility lines. This equipment does a very fine job in making possible a high over-all load factor on our purchased power, giving us a load factor of approximately 94 per cent. The power house also contains the equipment which totalizes the receipt of outside power, so that the total load purchased is known at all times. All load dispatching is done from this point. The fourth power house contains two 4375-kva, 13,000-v, 3-phase, 60-cycle alternators driven by turbines, taking steam at 625 psi, 725 F and exhausting into the steam distribution lines at 165 psig back pressure, after desuperheating. The generators operate in parallel with the public utility, but

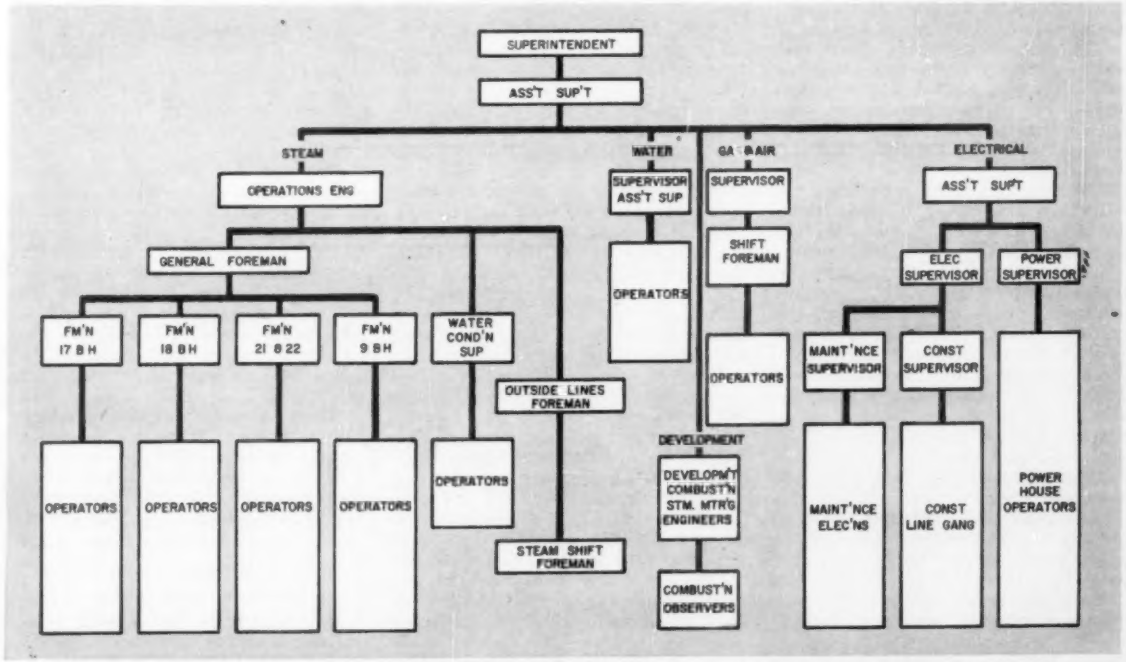
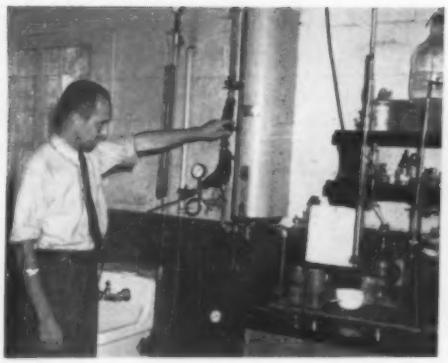


Fig. 7. Organization chart of Atlantic Refining Co.'s Power Dept. shows how varied maintenance work is divided by crafts



Figs. 8, 9, and 10. Water purity, maintenance of own sub-station, and steam metering all part of day's work for Dept.

are protected against feedback into the utility lines. These units have been very satisfactory and generate at about one-half the cost of purchased power.

A log sheet for the various power houses is shown in Fig. 14.

Steam Division is responsible for production of all steam produced by fuel-fired boilers, the distribution of this steam to consuming points scattered throughout the plant, the conditioning of feed water, and the assignment of locations for take-off of steam for the many purposes for which steam is used. Such uses are for power generation, steam pumps and turbines at the various units, processing, and, in the tank fields and other locations, for heating purposes. The division also maintains the steam traps servicing steam separators or other drips located at strategic points along the miles of pipe lines throughout the plant.

The steam is produced in five boiler houses located at different locations within the plant. Steam pressures are as follows: three boiler houses produce steam at 165 psig; one boiler house at 400 psig, and the latest and most modern house turns out steam at 650 psig and 725 F superheat.

One of the boiler houses, which contains four 350-hp boilers, is used primarily as a refuse disposal plant.

No entirely satisfactory method of handling mechanically all the various grades of material received at the refuse burning boiler house has as yet been evolved and manual labor plays an important part. The sludges are raised from the receiving pit outside the boiler house to the individual storage pits or bunkers in front of each boiler by a traveling crane. The material is then fed manually into the boiler furnace.

Two other boiler houses, one containing eight 750-hp boilers and the other eight 1000-hp boilers, are conventional fuel and gas fired units; they generate at 165 psi and feed into the general yard system. Another small house, generating 400-psi steam, was built especially for process purposes.

The latest and most modern house, consists of two 125,000-lb per hr and one 150,000-lb per hr boilers, generating at 650 psi and 725 F temperature. These boilers are also oil and gas fired. The steam produced is fed directly to the turbines formerly mentioned and exhausted at 165 psig into the yard system. Should a turbine be down, steam can be fed into the yard lines by means of a reducing valve. Automatic combustion control is provided.

Boiler House Log Sheet

A typical log sheet, which is used for the boiler houses is shown in Fig. 14. These log sheets are filled in by the shift engineers and then checked by the day foreman before they are processed for determination of steam produced.

Water for steam generating purposes is taken from the Schuylkill River and fed to the various processing units through the low-pressure water lines. After it has picked up heat in cooling the hot oil streams, or in condensing the petroleum vapors, it is piped back to the boiler-water conditioning plants. Due to the large area of the refinery and the many purposes for which steam is used, it has not been found economical to return condensate because of the piping required, except in those cases where large quantities of steam are condensed at one location. The feed water is therefore all make-up except for about the 10 to 15 per cent which is used for feedwater heating.

There are several different types of treatment, depending upon the use to which the water is to be put. For the 165 psi steam, a water which has been reduced to about 10 ppm hardness in batch treating plants using caustic soda and soda ash is fed to the boilers; an internal treatment using disodium phosphate in the boilers completes the treatment. For the 650 psi boilers, water is supplied through two Cochrane softeners, one of which uses phosphoric acid as a finishing treat while the other supplies water to an installation of hot Zeolite softeners recently installed, and which are not yet functioning completely. Our experience with the water finished by phosphoric acid has, however, been quite satisfactory.

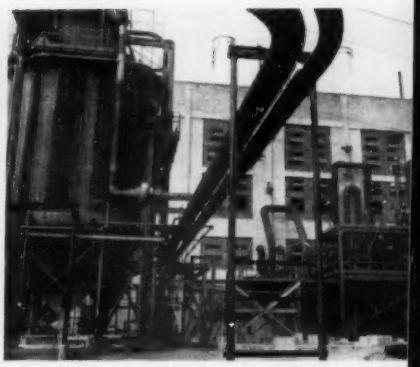
All steam leaving the boiler houses is metered, as are the larger consumers and areas throughout the plant, so that these consumers may be billed and cost of production of the various products determined. The quantities of steam, as determined from the charts of the recording meters, are tabulated by an accounting group outside the Power Department and monthly charges to the various operations are made by them with the assistance of the Power Department.

It can be easily realized that in a plant covering a large area, it is essential to know when and where new steam connections are made, what the quantity required will be, and how long, if temporary, use of steam will be required. To cover this, no steam connections are permitted without a Steam Connection Permit (Fig. 14) correctly filled in and approved. We have found that very definite steam savings have resulted from following these requirements carefully.

Gas and Air Division is charged with (a) the collection of gas produced by the various refining units, (b) the compression and distribution of the gas to consuming units for fuel purposes after it has been stripped of valuable components, (c) the distribution of purchased natural gas, (d) the compression and distribution of all compressed air throughout the plant for mechanical, process, and other uses.

There are three gas compressor houses, one gas exhauster house, and one air compressor house in the plant. The exhauster house maintains a suction on the stills and then transfers the crude gas to compressors which

Atlantic Refining Co. has made available a supply of the forms in Fig. 14. To get sample set, jot "Forms" on postcard or write the Editor, POWER ENGINEERING



Figs. 11, 12, and 13. Electrical repair, water supply problems, and maintenance of exterior steam lines add complexity

transfer it to units where the more valuable products are removed. After the gas has thus been stripped of its more valuable components, it is sent to the burning gas system to be used as fuel under the stills and boilers. The Gas Division handles about 47,000,000 cu ft per day. This consists of stripped hydrocarbon gases from the stills which are used as fuel, natural gas used as fuel, hydrogen for use by the Ammonia Plant, hydrogen sulphide used in acid production.

To take care of fluctuations in supply, two gas holders, one of 1,000,000 cu ft and one of 600,000 cu ft capacity are available.

A Gas Shift Foreman's report is also shown on Fig. 14.

There are twelve air compressors, varying in capacity from 2700 cu ft per minute to 350 cu ft per minute. Four are gas-engine driven, two are steam-driven and six are motor-driven.

The two yards are connected by a 6-in. pipe line so that load may be shifted as required. Average output is around 10,000 cu ft free air per minute at 90 psi pressure and is carried over the entire plant for mechanical repairs of all kinds. To supply the part of the plant on the west side of the Schuylkill River, a 4-in. line under the river is provided.

Water Division has charge of the pumping and distribution of the river or low pressure water used for process purposes, and the distribution of city water for drinking and sanitary purposes throughout the plant; it inspects and is responsible for the maintenance of all plant fire pumps and the inspection for general maintenance conditions of all Power Department buildings.

The service or low pressure water is supplied from two main locations with separate water intakes, screens, etc. All requests for additional quantities or new connections must be requested on forms provided and approved for location and quantity by the Power Department (Fig. 14). The demand for water varies with its temperature, since most is used for cooling purposes, but the average output is approximately 45 mgd during warm weather. The former quantities of up to 60 mgd have been reduced by use of cooling towers.

Drinking water is obtained from the city mains and boosted in pressure for distribution to all sections of the plant. There are at present four separate locations where water enters the plant from the city lines.

Development Group: This group consists of a Development Engineer, Combustion Engineer, a man charged with steam metering, and four Combustion Observers. The Combustion Observers Group is continually engaged in making flue gas analyses of the boilers and stills throughout this plant. From the results obtained, suggestions as to damper adjustment, burner operation, and any other pertinent facts regarding combustion in each particular furnace, are made. During these tests, inspections of brick work, insulation, etc., are performed and, where repairs are necessary, these conditions are noted. In a refinery where an equivalent of approximately 12,000,000 gal. of fuel oil per month are consumed, the savings realized from the operation of this group have been amply justified. A typical form for recording the observations of the Combustions Observers is shown in Fig. 14.

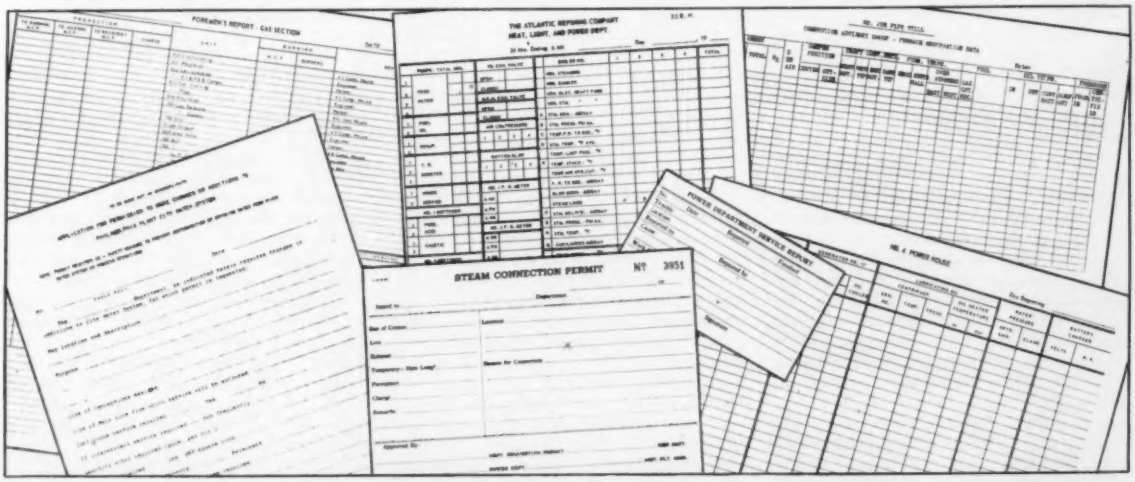


Fig. 14. Types of forms used by Power Department to regulate and control diverse maintenance and production operations

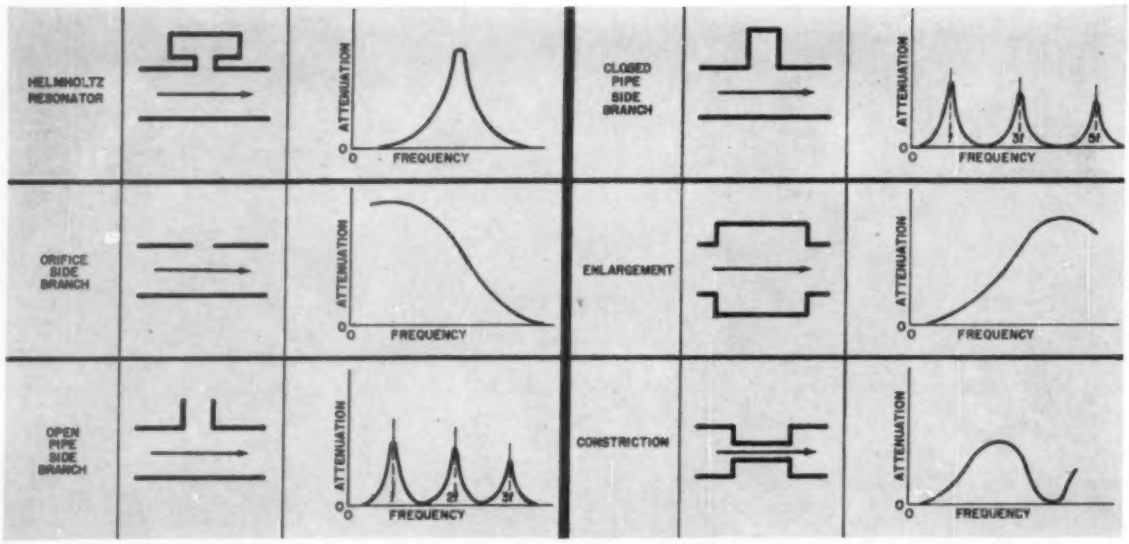


Table I. Characteristics of some typical ways of modifying exhaust piping in order to attenuate stack discharge noise

How To Reduce Exhaust Noise . . . Part II

Last month's article on exhaust noise reduction described the use of acoustical material to absorb excess sound. Here the principles and application of resonant chambers or snubbers are discussed

By NORMAN L. MEYERSON *

REMOVING narrow bands of frequencies can be accomplished by the use of resonant chambers or mufflers. In all cases resonant chambers act to send back into the stream an out-of-phase pressure wave to attenuate specific narrow frequency bands of sound being carried by the exhaust fluid. Design of the resonator section involves basic Helmholtz relationships such as the one demonstrated in Fig. 1. The reduction of the tuned frequency transmission follows the typical mechanical resonance curve as shown in Fig. 2. Application of the formula, Fig. 1, will result in specific frequency reductions with excellent test agreement provided the radius-to-length (thickness) ratio of the aperture to the resonant chamber is large. Since the volume of the chamber is the significant consideration, wide selection of chamber shapes to suit design requirements is permissible. The resonance peak for a closed chamber system is relatively broad, covering better than two octaves, which is desirable for exhaust treatment. Any number of chambers of the same or different volumes and aperture sizes may be combined to make up an exhaust muffler exhibiting even broader frequency attenuation. An example of this is shown in Fig. 3.

Other attenuation devices involving modifications to the exhaust piping are shown in Table I together with their energy — attenuation curves.

Commercial attenuators or mufflers generally contain a combination of these designs.

Terminal Treatment

Although stack treatment may have very effectively reduced specific components of the system noise carried by the gas stream, additional disturbance may be created by turbulence set up at the point of discharge of the exhaust gas to the atmosphere, particularly where terminal velocity is excessive. A simple technique to reduce this terminal noise uses a lined chamber with a splitter vane as shown in Fig. 4.

Many other devices, not necessarily constructed with acoustical material, are available to cope with terminal noise problems. One such example is shown in Fig. 5.

Before attempts are made to determine the proper terminal attenuator it is necessary to establish if the problem is one of pure terminal noise or not. Where noise is generated upstream of the terminus, treatment should proceed as described in last month's article in noise reduction. Although a terminal attenuator can absorb both system noise and terminal noise, it is entirely practical and advisable to handle each type of noise individually. Thus, it is not unreasonable to expect to see two types of mufflers in use in one stack.

Low frequency throaty exhaust sounds created by a throttling valve, nozzle, or orifice in a large diameter exhaust line or stack may be effectively reduced by altering the frequency spectrum of the disturbance and absorbing the resulting sounds with absorption material. For example, consider the case of an exhaust stack of large enough proportions such that the terminal noise due to exit velocity is at a minimum. Just ahead of the base of the stack or contained within the stack is a throttle valve necessary to provide a back pressure on the system. Exhaust gases passing through the throttle valve produce a rushing sound of wide frequency composition. Because of the large stack a throaty roar is heard emerging from the top of the stack. One approach to the solution of this problem is to install perforated plates in the stack just above the throttle valve with perforations sized small enough to create high velocity exhaust noise. Having now moved the range of frequencies to the high end maximum use may be made of acoustical materials in the stack between the perforated plates and the stack terminus Fig. 6. Attenuation in the order of 10 to 15 decibels can be expected near the stack terminus.

Proper application of the method outlined above either individually or in some combination will reduce exhaust disturbance satisfactorily

In most cases acoustical energy radiates from the exhaust pipe wall over its full run from the operating machine to the stack. Where a considerable length of this pipe is re-

* Manager, Research and Development Dept., Worthington Corporation

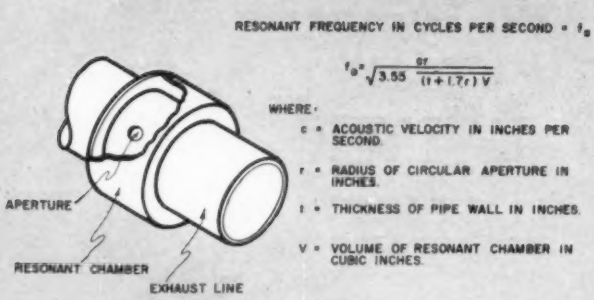

RESONANT FREQUENCY IN CYCLES PER SECOND = f_o
$f_o = \sqrt{3.55 \frac{ar}{(1+1.7r)V}}$
WHERE:
c = ACOUSTIC VELOCITY IN INCHES PER SECOND.
r = RADIUS OF CIRCULAR APERTURE IN INCHES.
t = THICKNESS OF PIPE WALL IN INCHES.
V = VOLUME OF RESONANT CHAMBER IN CUBIC INCHES.
APERTURE
RESONANT CHAMBER
EXHAUST LINE

Fig. 1. Helmholtz resonant chamber and formula for finding resonant frequency

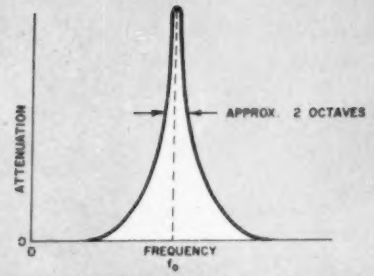


Fig. 2. Typical frequency-attenuation response curve of a resonant chamber

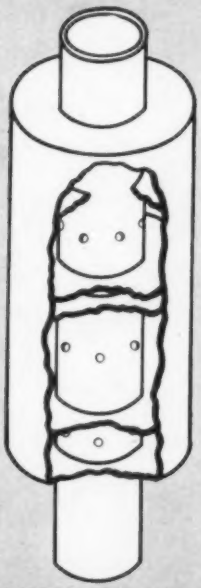


Fig. 3. Combinations of resonant chambers cover broad frequency range

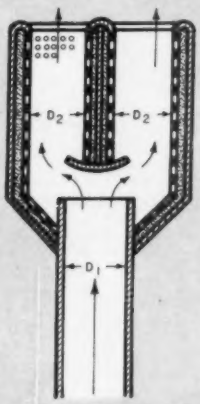


Fig. 4. Resonant chamber and splitter vane covered with acoustical material

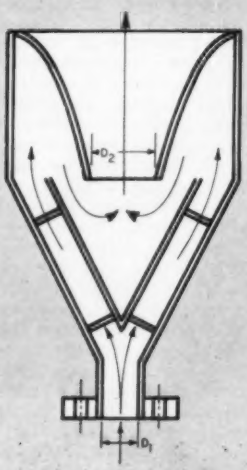


Fig. 5. Another type of resonant chamber used without acoustical material

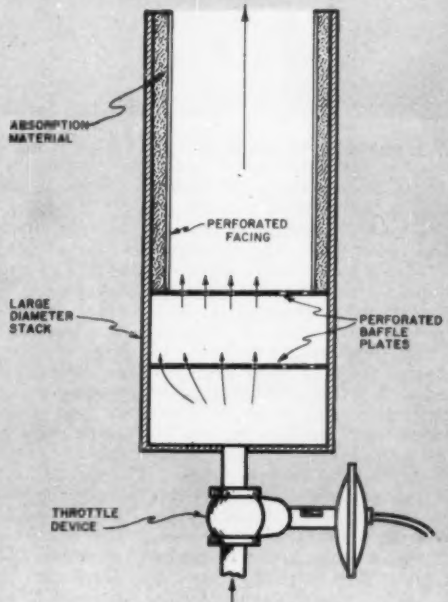


Fig. 6. Noise frequency raised by baffle then absorbed by acoustic material

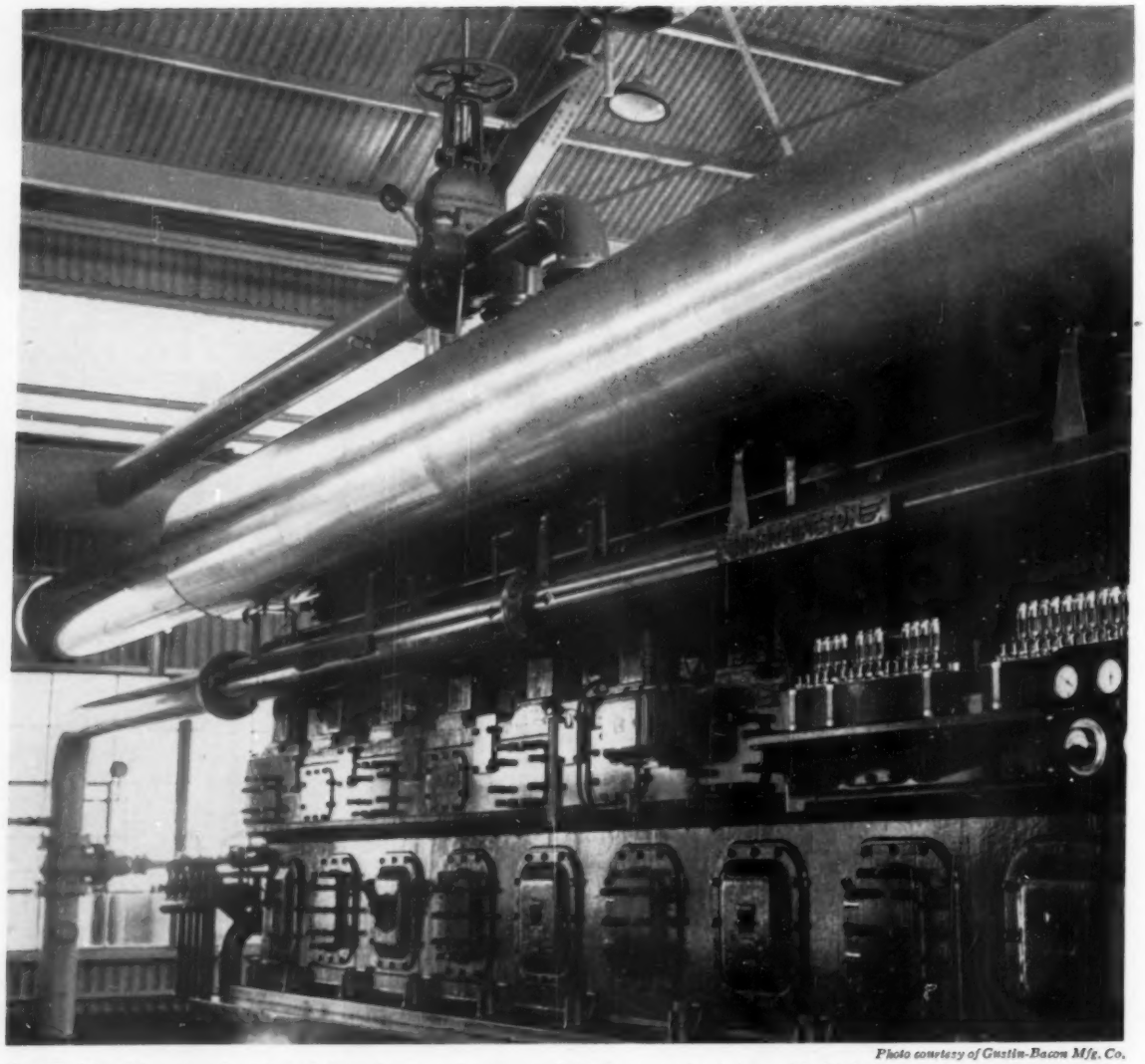


Photo courtesy of Gustin-Bacon Mfg. Co.

Fig. 7. Absorbing sound radiated from large exhaust manifold by covering pipe with thick layer of acoustical material

quired to be located within the building, sound radiation from the wall of the pipe can be a serious source of acoustical energy in the building proper. This is particularly so when the building is reverberant (that is: having very little absorption) and there are several runs of exhaust piping from operating machines. If the exhaust line has been properly provided with internal treatment little acoustical energy remains to be transferred from the flowing gas to the pipe wall. When internal treatment is impractical due to temperature or velocity, external coverings may be applied to good advantage. The covering material must be relatively massive to damp the vibration of the pipe. This is readily accomplished with many high density acoustical materials available in preformed or batt forms. Large area flat sections on exhaust lines such as blank flanges are particularly bad actors. Two to four inches of absorption material of densities from 6 to 10 lb per cu ft will suffice for most installations. A tight-fitting outer covering of sheet steel or aluminum should be applied around the external covering. This covering acts to provide mass loading of the outer layer of acoustical material and to reflect back a good portion of the residual acoustical waves remaining after passing through the absorbing layers. A typical example is one recently employed on exhaust manifolds of several large gas engines (Fig. 7). The manifolds were completely covered with three inches of 7.5 lb per cu ft glass fiber preformed to match the diameter of manifolds and an outer skin of 0.032 in. solid sheet aluminum. A resulting 6 to 8 decibel reduction was obtained throughout the range of higher frequencies (1200 to 10,000 cps).

Where several exhaust lines run within one building it is imperative that all simultaneously operating exhaust lines be sound treated before an evaluation of the treatment is made. Because of the nature of the decibel function an otherwise excellent treatment may be subject to false interpretation. For example, consider the case of six sources of noise within a building each one contributing 90 decibels to the over-all level. The room level, when all units are operating will be as shown below:

1 operating — 90 db
2 operating — 93 db
3 operating — 94.8 db
4 operating — 96 db
5 operating — 97 db
6 operating — 97.8 db

If one of the six operating units were to be completely shut down the maximum reduction in noise level to be expected would not exceed 0.8 decibels. It is obvious then that any sort of sound treatment on only one of the six sound sources would result in a room level change of no more than 0.8 decibels.

What You Can Do About

Organic Fouling in Your Deionization Units

Organic fouling of deionizers is relatively rare—compared with other water problems—but here is how to recognize it when it does occur, how to avoid it, and how to stop it if it gets a foothold

By F. X. McGARVEY and J. W. MOFFETT *

BEFORE 1940, boilers of 1200 psi were uncommon, while those of 2000 psi were practically unknown. Modern plants of the '50s have progressed until boiler pressures of 1500–2000 psi are commonplace. In the near future, supercritical pressure plants will be operating at pressures in excess of 5000 psi.

Naturally, increased temperatures and high heat fluxes have resulted in serious problems at the water wall. These problems are closely associated with the quality of the boiler feedwater. As pressures increase, the specifications on boiler water supplies become more stringent. Zero hardness, careful pH control, and total dissolved solids in the range of 1 to 2 ppm are common requirements. Values of 0.01 to 0.1 ppm of silica in the feedwater are frequently requested to maintain the silica concentration in the boiler water at the level recommended by the manufacturer.

What Resins Can Do

Introduction of strong base resins, such as Amberlite IRA-400 and 401, made the removal of silica and the production of high-quality water both practical and economical. For example: a two-bed system of Amberlite ion exchange resins can produce water of 500,000–1,000,000 ohm-cm quality; a four-bed system can produce water of 1,000,000–4,000,000 ohm-cm quality; and a monobed (mixed bed) will produce water of 5,000,000–15,000,000 ohm-cm quality. Insofar as silica content of the finished water is concerned, the effectiveness of a multiple-bed system is primarily dependent upon the composition of the influent and the regeneration levels, while the silica content of the effluent from a monobed is practically independent of these variables under normal plant operating conditions. It is for this reason that many designers are specifying monobed installations.

Problems associated with capacity of the ion exchange and leakage of soluble inorganic salts have been controlled by improved regeneration techniques and design arrangements. Occasionally, however, quality loss and reduction in pH have been observed which could not be corrected by modification of operation.

This problem is confined to a very small percentage of the operating units and is attributable to the presence of appreciable quantities of organic material in the raw waters. These "organics" are the result of decaying vegetable matter and industrial wastes. After a period of operation these acidic organic materials appear in the effluent and affect both the resistivity and pH of high quality waters. This has been called organic fouling.

The term organic fouling, of course, is derived from the cause of difficulties rather than the effect. The operators of deionization plants that are experiencing organic fouling should look in the same direction for the solution to their problems. Organic fouling is a water problem and should be handled as such. However, only a relatively few water supplies pose potential problems. Normally, deep wells are free from organic materials but some surface and shallow well supplies contain high molecular weight organic compounds. Fortunately, not all of the latter sources foul resins and the trouble makers appear to be few in number.

There is one important factor to remember, however. That is, under fouling conditions the operating capacity of the resins is lower than the original design value only if the unit is operated to a conductivity endpoint. The occurrence of organic fouling does not normally result in leakage of inorganic ions such as sulfates, chlorides, or silica. Experience has shown that a fouled unit will exhibit rated capacity if operated to a silica ion breakthrough.

In many people's minds, organic fouling has been associated only with mixed bed operations. This is not the case. The strong base anion resins in multiple-bed systems also will leak organic materials into the effluent if operated on a water that will foul the same exchangers in a monobed unit. However, in the case of multiple-bed systems, the presence of "organics" in the effluent from a multiple-bed system is hidden by sodium leakage from the cation unit.

This sodium appears in the effluent as sodium hydroxide that affects the resistivity and pH to a far greater extent than the organic material. As a result, this specific type of organic fouling was not recognized until monobed, with its high resistivity and neutral pH effluents, found wide use.

Recognizing Organic Fouling

Any depreciation of quality or lowering of pH due to the presence of acidic organic compounds is immediately apparent in the effluent of a mixed bed unit, whereas the organics by-passing the exchangers in a multiple-bed system are masked by cation leakage. It is for this reason that the following comments are con-

Water qualities obtainable with various methods of deionizing and distillation

Type of Treatment	Quality (ohms/cm × 10^6)
Monobed (Mixed Bed)	5 to 15
Multiple Bed	
four bed system	1 to 4
two bed system	0.5 to 1
Distillation in Quartz	
28 distillations	23 *
3 distillations	2 plus
Distillation in Glass	
3 distillations	1
1 distillation	0.5
USP distilled water **	0.1 to 0.5
Water in equilibrium with CO_2 in atmosphere	0.7
THEORETICAL MAXIMUM QUALITY (CALCULATED)	26

* Ion Exchange Development Group, Rohm & Haas Company, Philadelphia, Pennsylvania

* Kohlrausch, 1894
** The U. S. Pharmacopoeia specified that USP distilled water must not contain more that 5 ppm total dissolved solids.

fined to organic fouling as it concerns mixed bed operations.

Although all cases of organic fouling do not occur in an identical manner, a general performance pattern has developed from field experience. Gradual drops in average pH values and peak resistivities are the first indications of organic fouling. Initially, the plant delivers high resistivity water of the order of 5,000,000–15,000,000 ohm-cm at a neutral pH.

After a period operation the peak resistivity will be lower during the run and the pH values will probably decrease a few tenths of a unit in the latter part of the run. Once the downward trend has been initiated, it usually continues with time. A leveling off of the resistivity at 500,000–700,000 ohm-cm is normal and the pH will range from 4.5–6.5.

Cause of Fouling

The time element appears to be the most variable factor in case histories of organic fouling. In some cases, organics will appear in the effluent almost immediately after the monobed unit is placed into service. In other cases, contamination may not be apparent for several months. The type and quantity of fouling substances which reach the ion exchange beds determine the time interval until fouling is apparent.

Water soluble organic matter exists in natural water supplies as the products of decaying vegetation and industrial wastes. Extremely complex mixtures of organic substances have been isolated from water — in some instances the concentrations range from a few parts per billion to several parts per million. These materials are partially oxidized and will vary markedly in composition depending on the time the supply has been impounded, the amount of oxygen in the water, the temperature, the time of year, and the type of vegetation surrounding the source. Color is not an indicator for fouling tendency, although waters of high color are usually difficult to deionize.

Many "organics" are too large to enter the ion exchanger matrix and immediately appear in the effluent. Others, smaller in size, enter the resin structure but block the pores into the resin interior so that no further absorption of the fouling compounds is possible. Since these materials diffuse very slowly, the exchange sites at the interior of the resin cannot be freed from them during the relatively short regeneration step and the fouling compounds soon appear in the effluent during the exhaustion step. The rate of increase in conductivity cannot be predicted, but may occur after 1 or 100 cycles, depending upon the type and quantity of organic contaminants in the particular water supply.

Unfortunately, there is no quick or easy test to determine whether a proposed feed water will or will not foul ion exchange resins. The only certain method to determine whether the organics contained in a water supply will foul strong base anion exchange resins is to operate a pilot plant. This, of course, may involve considerable expenditure of manpower and high cost. As more field information becomes available on different waters, the need for pilot plant work will further diminish.

If a water shows fouling tendencies, the best recommendation is to remove the organics by pretreatment before introduction into the ion exchange unit. Quite often a combination of several methods is required: prechlorination, coagulation with adequate retention time, and filtration have enjoyed excellent success.

With some waters, it is possible that chlorination alone would be sufficient to destroy the organic compounds. This conclusion should be verified for any specific water supply. It is quite possible with insufficient chlorination, inadequate retention time, or certain types of organic compounds, that greater difficulties would be experienced after chlorination because of the formation of chlorinated organics that have a higher fouling potential. In line with the same reasoning, if chlorination is used in conjunction with coagulation the water should be prechlorinated before the flocculation step.

Chief problem in conjunction with prechlorination has been the maintenance of residual chlorine contents for sufficient time to permit oxidation of all potential fouling substances. Chlorination to breakpoint with holding times over an hour is suggested.

Most successful and widely used pretreatment to remove organic compounds from the water supply is conventional coagulation. Although the exact chemical nature of the organic materials in a water is unknown, detailed study and extensive laboratory tests are rarely necessary to determine the most effective coagulants and techniques. Insofar as laboratory work is concerned, simple jar tests are frequently all that are required. In the majority of cases, conventional coagulants and techniques are used with only minor variations in coagulant concentrations, pH, etc. for different waters.

Cost of Pretreatment

Cost of pretreatment by coagulation varies widely with the size of the plant and quality requirements specified for the finished water. It is doubtful that a direct estimate can be made of the cost of special pretreatment, but standard pretreatment equipment cost has been estimated:

Coagulation	Operating Cost—0.15—1.5¢ per 1000 gallons. Equipment—(settling basins, controllers, chemical feeders, chlorinators, pumps, etc.)—$75,000—$125,000 per million gallons per day capacity.
Filters	Equipment—$40,000—$60,000 per million gallons per day capacity.

These figures give some indication of the additional costs to be expected for complete coagulation of influents to ion exchange equipment. Sufficient treatment to provide excellent deionization performance would increase the cost of finished water by 3–5 cents per 1000 gallons.

Activated carbon has been tried at several installations for the re-

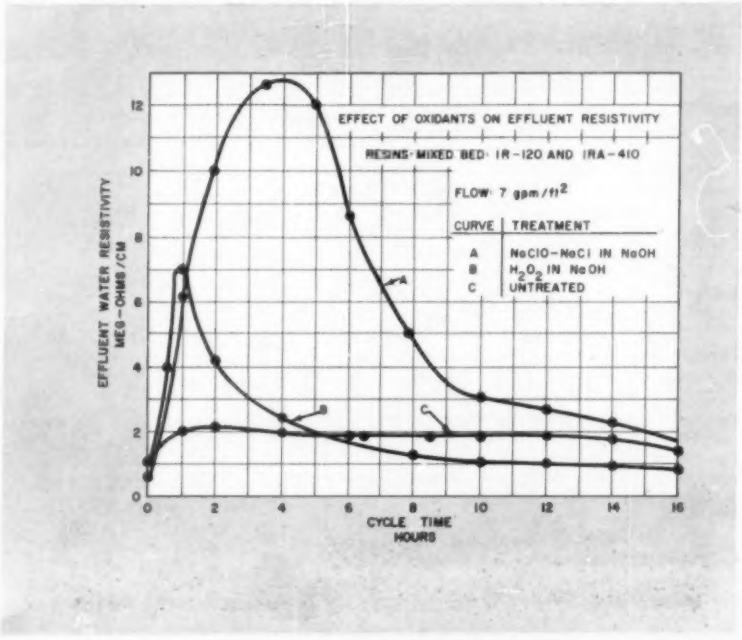


Fig. 1. Effect of various oxidants on the resistivity of effluents from mixed bed deionizers when the resins are contaminated with water-borne organic materials

moval of organics. However, this technique must be evaluated carefully. The reasons for this are:

1. There are several different types of carbon available, and each appears to be rather selective for different classes of organic compounds. It is conceivable that more than one type of carbon will be required to remove all the fouling materials.

2. Activated carbon completely removes offending compounds for only a very short period. After initial usage, organics will begin to leak through the carbon and foul the resins.

3. Regenerative techniques for activated carbon are difficult and expensive. The only effective method is to burn the carbon in a vacuum or an inert atmosphere.

Porous Anion Exchange Resins

Porous anion exchange resins such as Amberlite IRA-401 have been designed specifically for the adsorption of anions of high molecular weight. Despite the excellent results that have been experienced at some locations with the porous resins, they should not be considered a panacea for organic fouling. Some organic compounds are too large even to be adsorbed on and desorbed from these resins.

The porous resins have shown excellent results on difficult waters when used in conjunction with coagulation. The organic content of an influent is materially reduced by coagulation and the remaining traces are then picked up on a porous anion exchanger in a final polishing step. The small amounts of organics picked up by the resin in this manner are normally desorbed during regeneration.

In one instance, substitution of a porous resin was the complete answer to organic fouling. A pilot plant was installed to obtain information for the design of a major plant. After approximately 30–40 cycles, the standard strong base resins initially installed exhibited all the characteristics associated with organic fouling. With this preliminary experience, porous Amberlite IRA-401 was substituted. After this change, the unit operated satisfactorily and produced high quality water for over a year. The only special rejuvenation technique needed was an occasional triple caustic regeneration. Now the major plant has been installed with porous resins and is operating as predicted from the pilot plant results.

In other instances, substitution of a porous resin for a standard anion exchanger did not entirely eliminate organic fouling. The volume of acceptable water produced was increased before fouling became apparent. Also, special regenerative techniques were more effective in maintaining satisfactory operations.

Nevertheless, with some waters the porous resins will eventually foul. This being the case, a plant operator should consult an equipment manufacturer who is familiar with resins, equipment, available water supplies, and operating procedures before selecting or substituting a porous resin for the standard anion exchangers.

How to Cure Fouled Resins

If the anion exchangers become fouled, they can be reactivated by devising a regeneration technique which will remove the organic matter without causing permanent damages to the exchanger. Special regenerative techniques have included treatment with warm sodium chloride solution, but these have been only partially successful. A more drastic treatment using dilute peroxide or bleach solutions has been found to be the most successful in rejuvenation of fouled beds.

The recommended procedure is:

1. Regenerate the bed with sodium hydroxide to remove the silica and other anions.

2. Convert the resin to the chloride form with 5 pounds of sodium chloride per cubic foot as a 5–7 per cent solution at a flow rate of 1 gallon per cubic foot per minute.

3. Completely displace the brine with a solution of 0.25–0.5 per cent sodium hypochlorite containing 1 per cent sodium hydroxide.

4. Allow oxidizing solution to remain in contact with the resin a minimum of 6 hours and preferably longer.

5. If the oxidizing power of the solution is rapidly depleted, new solution should be added.

6. Once more, contact the resin with 5 pounds of sodium chloride per cubic foot as a 5–7 per cent solution at a flow rate of 1 gallon per cubic foot per minute. This step usually removes a large amount of color bodies from the resin.

7. Give the anion exchanger a double caustic regeneration separated by a short rinse.

The chemical requirements for the oxidizing treatment are 0.16 pounds of bleach, 3–3.5 pounds of salt, and about 0.6 pounds of caustic per cubic foot of bed treated. The chemical cost amounts to about five cents per cubic foot. Oxidation under these conditions has but slight effect on the capacity of the anion exchanger. However, if applied repeatedly reduction in capacity will result. The economics of this treatment are such that it becomes impractical to apply the technique more than once a month. Many instances have been observed where an occasional bleach treatment will permit satisfactory operation over long periods of time.

Eight Firms Coöperate to Solve Acid Waste Disposal Problem

THE PERENNIAL problem of treating and disposing of waste sulfuric acid pickling liquors from steel operations is being tackled by eight major companies in the metallurgical industries. The companies have announced plans to co-sponsor the building and operation of a demonstration plant which is expected to prove a practical solution to this vexing disposal problem.

The undertaking is a cooperative venture by Blaw-Knox Co., Jones & Laughlin Steel Corp., National Steel Corp., Pittsburgh Steel Co., Republic Steel Corp., United States Steel Corp., Wheeling Steel Co., and Youngstown Sheet and Tube Co. The pilot plant, a semicommercial unit rated at 650 tons of sulfuric acid per year, will be erected at the Niles, Ohio, plant of Republic Steel Corp. Blaw-Knox Co.'s Chemical Plants Division is proceeding with engineering, construction, and operation of the facilities. Initial operation is scheduled for late summer of 1956.

A great deal of research has been conducted on the treatment and disposal of pickle liquor, the volume of which is now estimated to be more than 600,000,000 gal per year in the United States. The customary treatment at present is neutralization of the acid waste with alkali and discharge of the resultant sludge into lagoons where the material is dewatered. This is an unsatisfactory process because of its high cost and the accumulation of large quantities of sludge which eventually must be disposed of by other means.

The Blaw-Knox Ruthner process, which will be demonstrated in the new facility, aims at a positive answer to the problem by yielding only reusable materials with no byproducts. In the Ruthner process, the entire sulfate equivalent of the waste pickle liquor is regenerated as fresh sulfuric acid. Iron is recovered as essentially pure iron oxide which can be recharged to the blast furnaces.

"Let me know when you get it figured out"

How Can We Prevent Steam Turbine Erosion and Corrosion?

In spite of great advances in steam turbine design, erosion and corrosion continue to present serious problems. Here are some of the lines along which these problems are being attacked

By F. H. PENNELL *

PRACTICALLY ALL steam turbine operators and manufacturers have encountered problems involving erosion and corrosion in steam turbines. The presence of moisture in steam sometimes makes these problems difficult to overcome, but present research, centered around improvements in design and treatment of blade materials, is making considerable progress.

Although the terms corrosion and erosion are frequently confused and the effects are sometimes combined, deterioration due to moisture can be grouped into the following three general catagories:

1. Corrosion, in which a chemical change takes place on the surface of the metal, sometimes penetrating the grain boundaries and becoming subsurface. This is more prevalent in parts other than blading, and is usually caused by bad operation or very poor steam conditions. A striking example of the effects of corrosion is shown in Fig. 1.

2. The second type is a combination of corrosion and mechanically abrading forces which remove the softer corrosion products, exposing new surfaces to corrosion. This is often difficult to distinguish from pure corrosion or erosion. Before 12 per cent chromium steel became the commonly accepted standard for turbine blades, blades made of low alloy steels tended to corrode and then erode quite rapidly under the scouring action of steam and water droplets.

3. Erosion is the third type, primarily destructive of the surface due to mechanical abrasion, in which water droplets strike the surface with sufficient force to cause breakdown. It usually occurs in the later low-pressure stages or below atmospheric pressures on the back of the leading edge of the blading, when the linear speed of the blading is in excess of 800 ft per sec and when moisture amounts to ten per cent or more. This type of deterioration is shown in Fig. 2.

Progress in combating erosion deterioration in steam turbine blades has been made by design improvements. Fig. 3 shows an early design with no provision for moisture extraction, and Fig. 4 shows a later design in which small orifices along the lower portion of the turbine casing drain water out of the casing. Lips take care of the drainage and also carry away water thrown off the rotating wheels.

It is not possible to remove all the moisture through turbine design. The most promising possibilities lie in improving the surface of the blade and current experiments in this direction fall within these categories:

1. Improving the mechanical characteristics of the material so that it may better withstand the forces of the water droplets. This might be done by using 12 per cent chromium steel with a modified heat treatment, in which tempering would be in the region of 600 F. The resulting hardness is then about 375 to 400 Brinell instead of 200 to 240 Brinell as in the conventional heat treatment, and an izod impact strength of about 35 ft lb is obtained instead of 60–80 ft lb. Such treatment presents some problems in the machining of fastenings. Designs would have to be free of stress concentrations and blade endurance limits would have to be checked. An alternative to this treatment might be to flame-harden the area subject to deterioration forces.

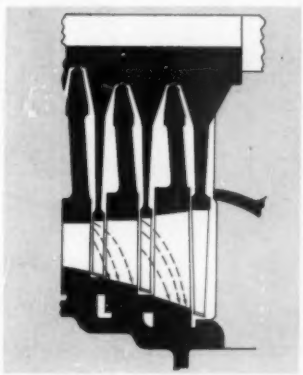
Fig. 1. Shows an example of pure corrosion on a turbine sealing gland, caused by condensed steam left standing in the turbine following test runs

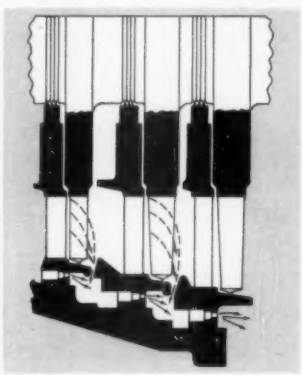
* De Laval Steam Turbine Company

Fig. 2. Left. Shows effect of water droplet erosion on turbine blading made of chromium stainless steel

Fig. 3. Below left. Early turbine design without provision for extracting moisture in low pressure staging

Fig. 4. Below right. Later design with provision for extracting moisture from the low pressure staging





However, this method would leave a heat-affected zone adjacent to the hardened zone, with the resulting material having doubtful qualities.

2. Application of a separately cast or wrought strip to the blade. This method, in which a strip of high-hardness, high-alloyed material is silver-brazed to the surface, has been widely used. The principal difficulty is in producing good fit-ups, so that the strip does not become detached and cause damage in the turbine. Application of strips must be carefully controlled to secure a high-quality bond. A danger in this method is the possible danger of overheating the blade and consequent damage to the mechanical properties. Fig. 5 shows turbine blading fitted with cobalt-chromium erosion shields.

3. Direct application of high-alloy compositions of the cobalt-chromium and nickel-boron types. This has not been widely practiced in the U. S. The hazards of direct application of these materials are due to the possible grain growth of the base material. Grain growth can be combatted by applying materials of low melting point and/or completely re-treating the blade after deposition. From the point of view of brittleness of the material, the nickel-boron type, due to its lower melting point, may offer some advantages over the cobalt-chromium type.

Both materials, in powder form, may have great possibilities. Finely powdered granules of the material are sprayed on the surface to the required thickness, after which the powder is fused to the blade. The smoothness and surface conditions of these deposits can be controlled much more easily than in a method based on use of the conventional rod and acetylene torch.

Investigations of all these possibilities is continuing, and may eventually find application. At present, the separately cast or forged strip is still favored, but indications are that higher resistance to corrosion and erosion will result from investigations now being conducted along the line of direct application of material to the blade.

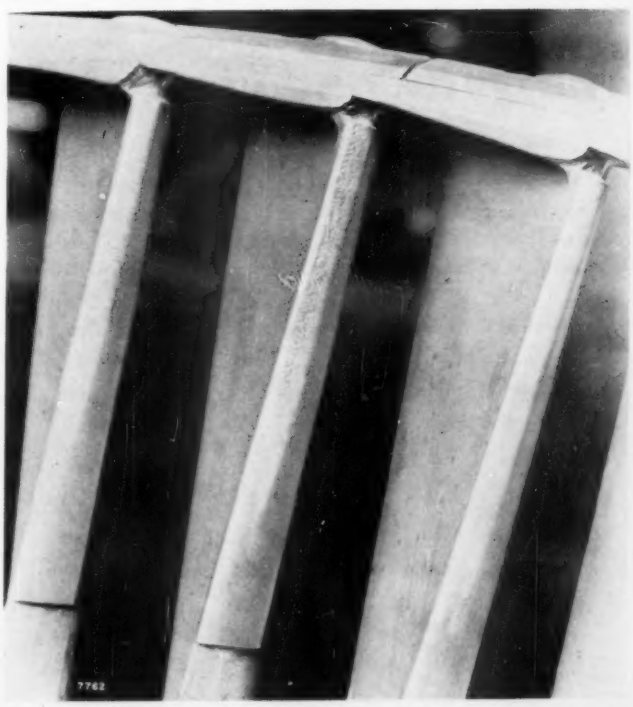


Fig. 5. Shows effect of water droplet erosion of cobalt chromium alloy. Note protective shields fitted to edges of turbine blading

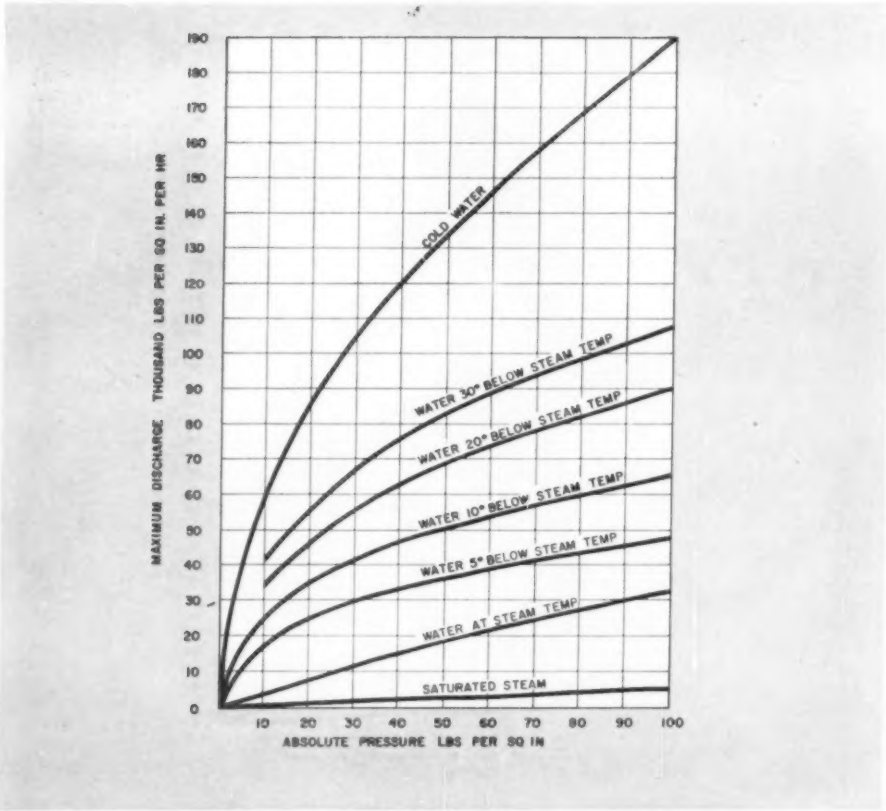

MAXIMUM DISCHARGE THOUSAND LBS PER SQ IN. PER HR
ABSOLUTE PRESSURE LBS PER SQ IN
COLD WATER
WATER 30° BELOW STEAM TEMP
WATER 20° BELOW STEAM TEMP
WATER 10° BELOW STEAM TEMP
WATER 5° BELOW STEAM TEMP
WATER AT STEAM TEMP
SATURATED STEAM

Fig. 1. Relation between condensate handling capacity at various condensate temperatures. Curves based on test data for an orifice with area of 1 sq in.

The Why and How of Steam Trapping

II. Selection—Sizing—Application

Last month's article on steam traps discussed modern construction and operation. Here selection, sizing and application are explained. Next article in series will be on maintenance and trouble shooting

Table I. Values of x = (T-t)/L used in text formulas for figuring trap loading

Pressure, psig	Temperature rise, F								
	40	60	80	100	120	140	160	180	200
5	0.042	0.062	0.083	0.104	0.125	0.146	0.167	0.187	0.208
10	.042	.063	.084	.105	.126	.147	.168	.189	.211
15	.042	.064	.085	.106	.127	.148	.169	.191	.212
20	.043	.064	.085	.106	.128	.149	.170	.192	.213
25	.043	.064	.086	.107	.129	.150	.172	.193	.214
30	.043	.065	.086	.108	.129	.151	.172	.194	.215
35	.043	.065	.087	.108	.130	.152	.173	.195	.216
40	.044	.065	.087	.109	.130	.152	.174	.196	.218
50	.044	.066	.087	.110	.132	.154	.176	.198	.219
60	.044	.066	.088	.111	.133	.155	.177	.199	.221
75	.045	.067	.089	.112	.134	.156	.179	.201	.224
100	.045	.068	.091	.114	.136	.159	.182	.204	.227
125	.046	.069	.092	.115	.138	.162	.184	.207	.230
150	.047	.070	.093	.117	.140	.163	.187	.210	.234
175	.047	.071	.095	.118	.142	.165	.189	.213	.236
200	.048	.072	.096	.120	.144	.167	.191	.215	.239

By JOHN W. WELKER *

NORMAL SELECTION OF a steam trap depends on the answers to two questions: (a). What type of trap can best be used? and (b). What is the correct size of trap to use?

To answer these questions the trapping problem frequently requires detailed analysis. Each type of trap has certain limitations. Here are some factors which govern selection, application, and successful and continuous operation of a trap.

1. Pressure or range of pressure at inlet: Pressure and condensate handling capacity are directly related in all traps. In some designs, varying pressure limits use. Only by change in valve parts can a bucket trap be used above a limiting pressure set by the weight of the bucket. In a metallic expansion trap at a given

* Application Engineer, Yarnall-Waring Company

Table II. Data for use when heat exchanger has excess surface which heats liquid in less time than required by process

Mtd ° °	Btu/sq ft/hr	Pounds per hour per square foot — Steam pressure, psig → 1	5	25	50	100	150	200	250	300	350	400	450	500	600 ←
10	280	.28	.29	.30	.31	.32	.33	.33	.34	.35	.35	.36	.37	.37	.38
20	930	.96	.97	1.00	1.02	1.05	1.08	1.11	1.14	1.16	1.18	1.20	1.22	1.24	1.28
30	1,900	1.96	1.98	2.03	2.08	2.16	2.22	2.27	2.32	2.36	2.41	2.45	2.49	2.53	2.61
40	3,100	3.20	3.23	3.32	3.40	3.52	3.62	3.72	3.78	3.85	3.92	3.99	4.06	4.13	4.25
50	4,500	4.65	4.68	4.82	4.93	5.11	5.25	5.38	5.48	5.58	5.69	5.80	5.89	5.99	6.17
60	6,250	6.45	6.51	6.69	6.86	7.10	7.30	7.47	7.62	7.76	7.92	8.06	8.18	8.33	8.53
70	8,000	8.26	8.33	8.57	8.77	9.08	9.34	9.56	9.75	9.94	10.15	10.32	10.47	10.65	10.97
80	10,400	10.73	10.83	11.13	11.40	11.80	12.14	12.43	12.67	12.92	13.17	13.40	13.62	13.85	14.26
90	12,500	12.90	13.00	13.37	13.70	14.20	14.60	14.94	15.24	15.53	15.83	16.13	16.36	16.65	17.15
100	15,000	15.47	15.62	16.05	16.44	17.03	17.50	17.90	18.28	18.63	18.97	19.34	19.64	19.97	20.57
125	22,400	23.10	23.30	23.95	24.55	25.45	26.15	26.75	27.30	27.80	28.35	28.90	29.30	29.85	30.73
150	30,000	30.95	31.20	32.10	32.90	34.10	35.20	35.85	36.60	37.30	38.00	38.70	39.30	39.95	41.15
175	40,000	41.30	41.65	42.80	43.80	45.40	46.70	47.80	48.75	49.70	50.65	51.60	52.40	53.30	54.85
200	50,000	51.60	52.10	53.50	54.80	56.75	58.30	59.70	60.90	62.10	63.30	64.50	65.50	66.60	68.60
250	82,000	83.70	85.30	87.75	90.00	93.10	95.70	98.00	100.00	102.00	103.70	105.70	107.30	109.30	112.50
300	100,000	103.30	104.00	107.00	109.50	113.50	116.60	119.40	122.00	124.20	126.50	128.80	131.00	133.30	137.00

* For copper, multiply table data by 2.0 For brass, multiply table data by 1.6 ** Mean temperature difference, F = temperature of steam minus average liquid temperature

Heat transfer data for calculating this table obtained from and used by permission of the American Radiator & Standard Sanitary Corp.

Table III. Radiation from heating surface $H(t_1 - t_2)L$ in lb of condensate /hr/sq ft used in formulas for obtaining trap loads

Air temp, F	Steam pressure, psig → 1	2	5	10	15	20	25	50	75	100	150	200	250	300	350	400	450	500	600 ←
32	.53	.54	.57	.70	.74	.78	.81	1.02	1.13	1.30	1.46	1.70	1.86	1.97	2.31	2.41	2.52	2.62	3.14
50	.48	.49	.52	.56	.68	.71	.74	.87	1.06	1.15	1.38	1.52	1.74	1.85	1.96	2.06	2.41	2.52	2.71
60	.45	.46	.49	.53	.56	.59	.71	.84	1.02	1.10	1.34	1.47	1.58	1.80	1.91	2.00	2.35	2.46	2.65
65	.44	.45	.47	.52	.55	.58	.69	.82	1.00	1.08	1.32	1.45	1.56	1.77	1.88	1.97	2.07	2.43	2.62
70	.39	.40	.45	.50	.53	.56	.59	.80	0.98	1.06	1.21	1.43	1.54	1.75	1.86	1.95	2.04	2.39	2.59
75	.38	.39	.44	.49	.52	.55	.58	.77	.88	1.05	1.19	1.40	1.52	1.62	1.83	1.93	2.02	2.11	2.56
Value of heat loss used (H)	2.6			2.8				3.2		3.5			3.75			4.0			4.5	5.0

* Based on still air; for forced-air circulation multiply above values by 5

Table IV. Overall coefficients of heat transfer. (Under many conditions higher or lower values may be realized)

Type of heat exchanger	Free convection, K	Forced convection, K	Typical Fluid	Typical apparatus
Liquid to liquid	25– 60	150–300	Water	Liquid-to-liquid heat exchangers
Liquid to liquid	5– 10	20– 50	Oil	
Liquid to gas*	1– 3	2– 10	.....	Hot-water radiators
Liquid to boiling liquid	20– 60	50–150	Water	Brine coolers
Liquid to boiling liquid	5– 20	25– 60	Oil	
Gas* to liquid	1– 3	2– 10	.....	Air coolers, economizers
Gas* to gas	0.6– 2	2– 6	.....	Steam superheaters
Gas* to boiling liquid	1– 3	2– 10	.....	Steam boilers
Condensing vapor to liquid	50–200	150–800	Steam to water	Liquid heaters and condensers
Condensing vapor to liquid	10– 30	20– 60	Steam to oil	
Condensing vapor to liquid	40– 80	60–150	Organic vapor to water	
Condensing vapor to liquid		15–300	Steam-gas mixture	
Condensing vapor to gas*	1– 2	2– 10	.....	Steam pipes in air, air heaters
Condensing vapor to boiling liquid	40–100	.....	.....	Scale-forming evaporators
Condensing vapor to boiling liquid	300–800	.....	Steam to water	
Condensing vapor to boiling liquid	50–150	.....	Steam to oil	

*At atmospheric pressure

setting, correct operation depends on a constant temperature which means constant pressure. An impulse trap is designed for a wide range of pressure without adjustment or change of parts.

2. Amount of air to be handled: Bellows, impulse, orifice, metallic and liquid expansion traps all have excellent air handling capacity. Some bucket traps incorporate thermostatically controlled air vents to permit handling large volumes of air.

3. Heat-up time required: If heat-up time is not important, a trap can be appreciably smaller than if the abnormally high amount of condensate formed on start-up must be handled quickly.

4. Type of discharge desired (continuous or intermittent): Ball float, metallic or liquid expansion, and impulse traps are suitable for application where continuous condensate discharge handling is desirable. Bel-

lows traps (except where flow and temperature are constant) and bucket traps normally have an intermittent discharge.

5. Required discharge temperature of condensate: Some traps handle condensate at or very near to steam temperature. Others require a differential in temperature called sub-cooling between closing on one cycle and opening on the next. Careful review of a trap should be made to determine condensate handling capacity at various temperatures below steam temperature.

6. Back pressure in return system: Increase in back pressure will normally decrease discharge capacity and in the case of some trap designs such increase is a limiting factor on proper application. This detail should be checked with the manufacturer.

7. Available space: Space normally is not a factor, but dimensions such as the length of a metallic expansion trap may be significant.

8. Maximum temperature expected at trap inlet: Bellows traps are not normally recommended for use on superheat, which places significance on maximum temperature to be expected at trap inlet.

9. Installation cost: Cost is usually insignificant when compared to the savings a properly applied trap can make. Certain types of traps that are comparatively large create excessive installation expense.

10. Maintenance cost: Simplicity of design, the number of moving parts, whether a trap can be serviced quickly under pressure — all are factors to be considered in maintenance. Once the **type** of trap has been selected, condensate load must be calculated to determine trap size. Trap catalogs tabulate capacity-pressure relations, and a study of such tables shows that capacity generally does not increase in direct proportion to the pressure differential across the trap. These tables will also show that body and pipe connection size are not true indices of capacity. In the case of the impulse design the manufacturer provides a very simple selector bulletin. Trap sizes can be determined quickly by using this selector without the necessity of first calculating amount of condensate. Load from steam apparatus is expressed in lb per hr of condensate formed. Load characteristics vary considerably. During start-up load is heavy as air as well as condensate must be removed in large quantities. Condensate is forming at a rapid rate during start-up because all parts of the apparatus and connected system must be brought up to temperature; and this condition usually results in a lower pressure at the trap inlet which reduces trap capacity when load is at its maximum.

When the system reaches operating temperature, condensate formation may be relatively constant, or it may vary considerably depending on the application. To compensate for some of these variables, a factor of safety must be used as a multiplier of calculated load to determine the final figure to be used as a selection from catalog capacity tables.

There are many methods to calculate load, but generally calculations involve the use of formulas such as those listed below — each formula designed for a specific type of application —

(1) $C = WSX$ Used for pressure vessels such as retorts, autoclaves, etc., where steam is applied directly to solid materials being heated.

(2) $C = WX + 970\ (W\text{-}D)/L$ Used for dryers, platen presses, etc., where steam loses its latent heat indirectly to solid material through metallic surfaces.

(3) $C = AY$ Used for pipe coils to heat air such as found in unit heaters and chamber dryers where steam loses its latent heat indirectly through a metallic surface.

(4) $C = KAX$ Used for submerged surface where quantity of liquid heated is unknown.

(5) $C = GWSX$ Used for submerged surfaces where the quantity of liquid heated is known. Here steam loses its heat through metallic walls of coil or other metal surface submerged in a vessel when liquid is being heated. Cookers, heat exchangers, etc., where steam loses its latent heat indirectly to a liquid through a metallic surface represent the type of equipment involved here.

Symbols used

C = Condensate lb per unit time

W = Weight of medium being heated in lb

S = Specific heat of substance being heated

$X = (T\text{-}t)/L$ (Table I)

$(T\text{-}t)$ = Temperature rise of substance heated in deg F (See Table I)

L = Latent heat of steam at trap operating pressure in BTU/lb

D = Weight of substance heated after drying — lb

A = Heating area — sq ft

Y = Radiation from heating surface $H\ (t_1\text{-}t_2)L$ in lb of condensate/hr/sq ft (See Table III)

H = Heat loss expressed in Btu/sq ft/deg F/hr

t_1 = Steam temperature at trap pressure—deg F

t_2 = Ambient air temperature — F

K = Coefficient of heat transfer (See Table IV)

G = Gallons of liquid heated per unit time

w = Weight of liquid being heated — lb/gallon

The formulae and data given above when applied to a specific problem will produce condensate load. The load must then be multiplied by a safety factor before trap capacity tables can be used to size the trap. These factors vary between 2 and 5 and take care of variations in steam pressure, discrepancies between assumed and actual data (the latter of which is rarely known), unpredictable and abnormal operating conditions, etc. Generally a factor of 2 applies to submerged coils discharging to gravity, and pressure vessels.

Dryers, pipe coils in air and submerged surfaces draining to a trap located above the surface take a factor of 3. Coils over which air is forced usually take a factor of 5.

Catalog recommendations should be followed for the type of trap selected. It is important to ascertain the temperature base on which catalog capacity tables are calculated. Since capacity decreases with rise in condensate temperature, the lower the temperature base, the higher the factor of safety must be.

The relation between condensate handling capacity at various condensate temperatures is shown in Fig. 1. These curves are based on test data for an orifice having an area of one sq in. If the area of a trap orifice is known, these curves can be used to approximate capacity (at a given pressure) by multiplying the orifice area in sq in. by the rate of flow from the appropriate curve, and then by an appropriate orifice coefficient.

Frequently heat exchangers contain excess surface which results in heating a quantity of liquid in a time less than the process calls for. This results in condensate being formed at a more rapid rate than expected. Special care should be taken to calculate the load under these conditions so that condensate is withdrawn as soon as it is formed to maintain highest efficiency. In these cases do not use formulae 4 or 5 but multiply the submerged area by the applicable factor from Table II to obtain the load.

"I keep squawking for a phone down here and they think they can satisfy me with this!?"

FIG 4

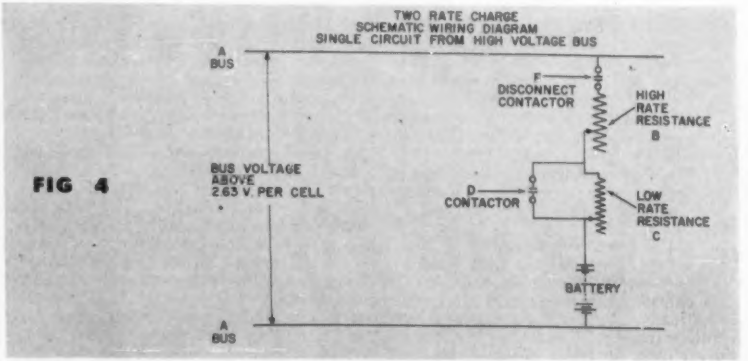


FIG 5

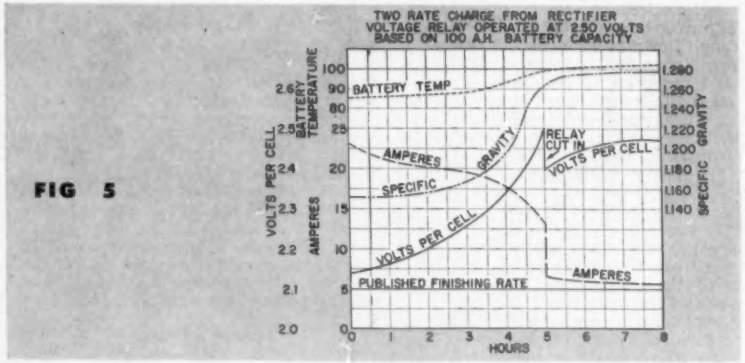
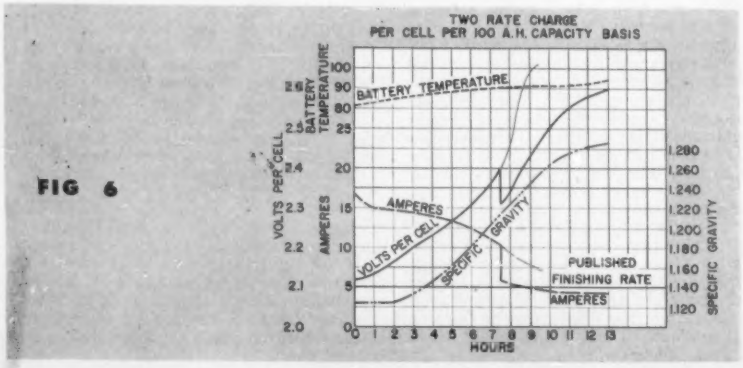


FIG 6



Power Engineering handbook

Charging Know-How Extends Battery Life and Reliability

By K. A. VAUGHAN *

THERE ARE several accepted methods of charging batteries. The selection of the charging method and equipment will be influenced by local requirements, work cycles, numbers of batteries, number of different sizes in the same plant, future expansion, plant layout and the like. It is important for economic battery life and performance to understand the characteristics of each method. Overcharging, finish charging at an excessive rate, overheating and too much gassing will lead to short battery life.

A discharged battery can absorb high charge rates at a relatively low battery voltage without gassing or high temperature rise. The amperes fed into a battery at the start of charge generally run about 4½ times the finishing rate. Most manufacturers agree that the finishing rate should not exceed 5 amperes per 100 amp-hr of capacity. The starting rate, therefore, is about 22½ amperes per 100 amp-hr for modified constant voltage charging. The recommended bus voltage is 2.63 volts per cell.

Modified Constant Voltage Charge

Modified constant voltage charging is designed to provide 2.63 volts per cell, starting rate of 22½ amperes per 100 amp-hr to a discharged battery and a finish rate of 5 amperes per 100 amp-hr. Equipment of this type is available for charging single batteries or for many batteries from one generator. Figure 1 shows a schematic diagram of equipment for modified constant voltage charging of four batteries. The shunt field rheostat D can be adjusted to vary the bus voltage and adjusting the fixed resistance K in each battery circuit will vary the charge rate.

Figure 2 shows what happens during the modified constant voltage charge. At the beginning of the charge, the ampere rate is a maximum (22.5 amps) and the volts per cell is at a minimum (2.11). As charging progresses, battery voltage rises which causes a reduction in the ampere rate. At the end of charge, the ampere rate is down to the published finishing rate of 5 amp or slightly below it.

The volts per cell is at the proper value for the battery to turn the motor of the industrial electric truck.

Specific gravity during the first two hours of charge remains practically constant. This is a normal characteristic even though during first two hours of charge the greatest amount of productive charging is accomplished. The increase in specific gravity lags because the electrolyte has not started to circulate. As the charge progresses and gassing occurs, specific gravity increases rapidly especially when the cell voltage is about 2.30.

During the "follow through" charge, the initial temperature was 83 deg F

* Manager of Field Engineering, Gould-National Batteries, Incorporated.

FIG 1

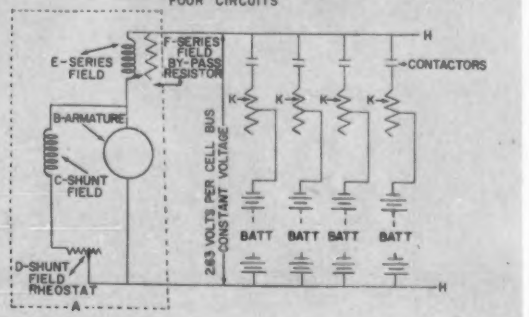


FIG 2

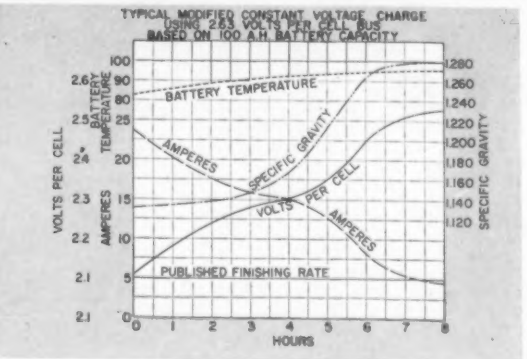
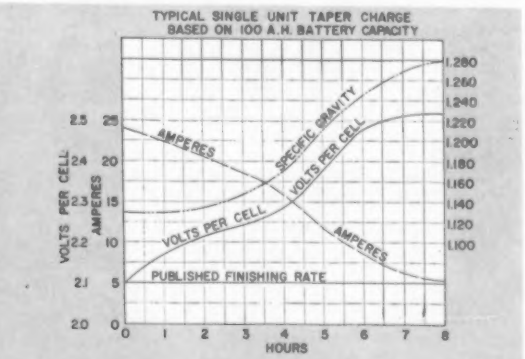


FIG 3



and at the end of charge the temperature was 96 deg F. This represents a 13 deg F rise in temperature during the charge. A 10 to 15 deg F rise in temperature during a recharge is quite normal. When a 15 deg F rise in temperature is exceeded during a charge, the equipment should be checked because something may be wrong and can be improved. Ventilation may be improved, or it may be that the charge rate is not correct.

Taper Charge

The taper charge is one that results when the battery is connected directly to the charging generator and the rate automatically tapers to a safe "end of charge" rate. At present it is only obtained from specially designed single unit generator using a drooping voltage characteristic.

Figure 3 shows the details of a "follow through" of a taper charge. The curves are similar to Fig. 2. A high ampere rate at the beginning of charge is obtained when the battery voltage is low. As the charge progresses and the battery voltage increases, there is a reduction in ampere rate. The end of charge rate is approximately finishing rate.

Two Rate Charge

The two rate method is one in which the charge rate is changed by mechanical means from that used during the first part of the charge to a safe rate for the end of the charge.

Figure 4 is a schematic wiring diagram for a two rate charge from a fixed bus voltage which is something above 2.63 volts per cell. "A" represents the bus, "B" — the high rate resistor in series with the battery, "C" — the low rate resistor in series with the battery, "D" — the contactor which shunts out the low rate resistor "C" during the first part of the charge. "F" represents the disconnect contactor which opens to terminate the charge. The starting charge rate can be adjusted by varying resistor B. The low rate charge can be adjusted by varying resistor C.

Figure 5 shows the "follow through" of charge. During the first part of charge, the ampere rate does not taper as much as with either modified constant voltage or taper charging. The amount of taper that occurs in this part of the charge depends upon the magnitude of the bus voltage. With a bus equal to 10 volts per cell, there will be practically no taper and the ampere rate during the first part of charge will be practically constant. Normally, the change rate contactor is actuated when the battery is approximately 80 per cent charged.

Figure 6 shows what occurs when the change rate control circuit fails to operate. The light dotted lines indicates the ampere rate and voltage which would result if the rate is not reduced from high rate to low rate. The end of charge rate is considerably above finishing rate and the cell voltage has increased. During this part of the charge there would be excessive gassing and considerable temperature rise. Obviously, the charging equipment must be checked when this condition occurs. Special attention should be given to the change rate control circuit.

Boost Charge

A boost charge is a special charge given to a battery in addition to the regular charge. It is usually given a battery operating under a heavy work load to permit high capacity performance throughout the entire shift. The boost is usually given at lunch time when the truck is idle to enable it to finish the day without perceptibly running down. Depending on the per cent of discharge, the boost is given at a high amperage rate.

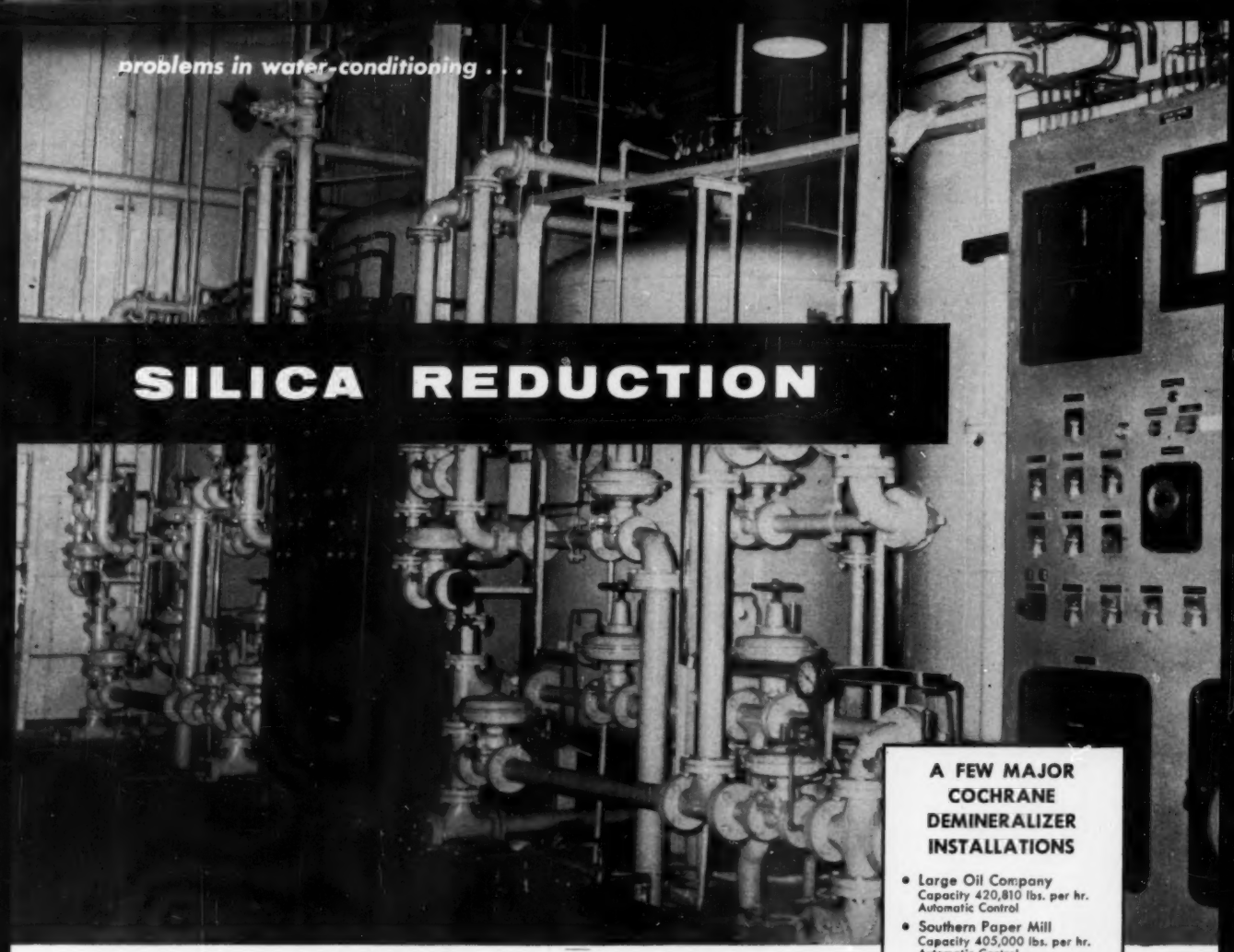
Only batteries which are substantially discharged during the morning should be given a boost charge. Avoid excessive gassing and temperature rise.

Equalizing Charge

This is a special charge at the finishing rate or less given in addition to the regular charge. Its purpose is to bring each cell up to the proper voltage. Batteries in daily, heavy service should get an equalizing charge once a week. For lighter service, batteries should receive an equalizing charge once a month.

The equalizing charge is given at the end of a regular charge or when the battery is in a fully charged state. The charge proceeds until all cells are gassing freely and uniformly and until four consecutive 1 hour readings of the cells and of the battery as a unit show no increase in specific gravity or voltage.

If the sp gr and voltage of any cell is below the others at the end of the equalizing charge, the cell should be removed from the battery for a detailed internal examination to determine and correct the cause.



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Power Engineering handbook

Toothless Band Saw Shows Benefits and Some Disadvantages

By JOHN ROUSH*

RYAN methods engineers have drastically slowed down the speed of friction sawing to uncover several important economic advantages. Made with inexpensive box strapping and clock spring materials, these studies varified what other companies have previously disclosed concerning the advantages of using "homemade" band saw blades. In addition, the Ryan investigations explored a new region of "slow speed" sawing techniques to reveal extra benefits which can be realized.

Ryan conducted its tests with several large Tannewitz band saws and several smaller Walker-Turner band saws. In these machines, ordinary box strapping (.050 x 3/8-in.) and inexpensive clock spring (.020 x 1/4-in.) were compared with conventional, toothed band saws in sawing a variety of gauges of stainless steel, mild steels and titanium. Saw speeds were varied from 2000 surface feet per minute to 15,500 sfpm.

Our investigators found that inexpensive box strapping and clock spring material will cut stainless steels, mild steels and titanium quite well. In every case, conventional, toothed saws will cut these metals at a faster rate. However, in many instances this is not an advantage because the toothless strapping will cut as fast as an operator can follow scribe lines.

*Methods Engineer, Ryan Aeronautical Co., San Diego, California.

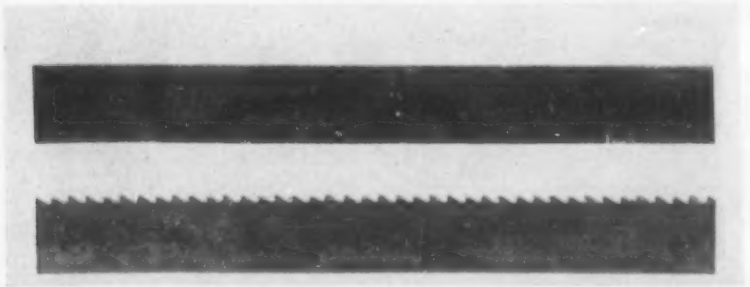

Fig. 1. Toothless and conventional blades. Toothless blade can be made of clock spring or metal strapping

Because the box strapping and clock spring are toothless, this material is more difficult to control in following scribe lines, than toothed saws. Ryan developed several guides which provide the required stability and control for the toothless sawing and which have also demonstrated their effectiveness in improving work done with toothed blading.

The principal advantages shown to exist when "homemade" toothless saws are used are:

1. **Longer life:** Toothless blading lasts up to ten times as long as conventional saws. This is due to the extended fatigue life which these cheaper alloys possess because the saws always fail from metal fatigue. This desirable longevity means far less work stoppages and machine "down time" to replace broken blades, though this is not so important in maintenance shops as in Ryan production facilities.

2. **Lower costs;** Reduced costs are realized through two factors. First, the toothless material costs only about 80 cents per blade, including welding, while conventional saws cost between $2.50 and $3.00 each. Second, the greatly extended life of the toothless saws add another cost advantage to their use. We estimate that direct material savings of approximately $225 per year per saw can be achieved with the less expensive material.

3. **Greater safety;** Although this is not a large factor because of the protective equipment which operators wear, there is a safety advantage attached to the use of toothless blades. Due to their physical properties, these blades always break with a collapsing, accordion-like, action. Conventional saws snap with a whip-like action which is more apt to cause injury to employees.

Certain disadvantages accrue to the use of toothless saws which must be weighed in each application to determine if the cheaper material should be used. Heavier pressures must be exerted by the operator in order to saw the parts, evidently due to the absence of the saw teeth which tend to "bite" into the metal. Substantially greater deposits of burr are formed because the smooth-edged blades do not remove the accumulated burr as well as the toothed edges. This necessitates added labor or processing for burr removal. Employees tend to resist the use of toothless sawing because they usually do not like the "feel" of the blade and because added pressure is often required to perform satisfactory work. This requires better training techniques in showing employees how to use the saws.

These advantages and disadvantages were indicated in experiments with the toothless blades operating at standard Tannewitz band saw speeds from 8500 to 15,500 sfpm. When Ryan explored the region below 8500 sfpm, two additional advantages were discovered which made toothless sawing more useful for certain types of work.

Ryan found that the minimum speed at which sawing could be accomplished was 2600 sfpm. The ideal speed for the work was discovered to be 4500 sfpm.

Fig. 2. Stainless steel is cut with low (4500 sfpm) blade speeds, permits use of smaller band saws. This blade is clock spring; outlasts toothed blade

Toothless blade sawing at these velocities presented these two advantages over higher speed ranges:

1. **Reduced burr;** Far less burr is caused at low speeds than is experienced when sawing within the 8500-15,500 sfpm range. Burr begins to decrease at 6500 sfpm and down. Burr greatly increases above 8500 sfpm. In most cases, the small amount of burr which results at 4500 sfpm is comparable with the burr accumulated when sawing with toothed blades.

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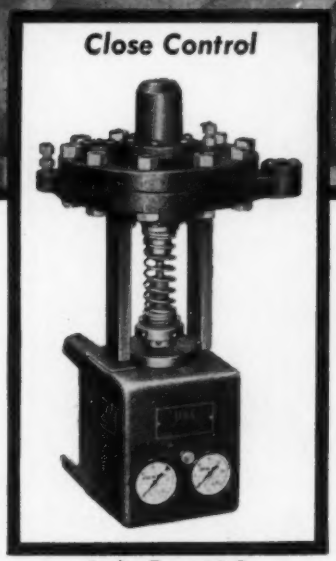

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2. **Lower costs;** Lower speeds permit the use of smaller, less expensive band saws. This reduces investment in equipment and provides greater flexibility in sawing operations. Another saving is due to the fact that these smaller saws require only 8 feet of blading compared with the 19½ feet of the larger models.

Ryan conducted a test with a large Tannewitz band saw in which speeds were reduced to 4500 sfpm and toothless blading was used. This was not satisfactory because of the heat generated by the blade which overheated the saw's steel tires. Possibly, the installation of rubber tires would correct this situation. Ryan also found that the larger saws exert pressure which connually tends to stretch the blade.

An interesting example of the usefulness of toothless sawing was a titanium job which methods engineers tackled. This involved the cutting of a T-shaped part from a forged titanium billet 6 x 6 x 8-in. Titanium experts had stated that it was impossible to friction saw this piece because of the tendency of titanium to drag and form hard titanium oxide on the saw blading.

We tried to do the job with a toothed saw. After 16 hours, only one-half inch had been cut and 20 saw blades were broken. With a toothless saw, the required 20 inches were cut in two hours and only three blades were used. The blades were "homemade" clock spring saws, operating at 4500 sfpm and powered by a 15 h.p. motor.

Previously, this had been a milling job. When the part was obtained, the metal removed was in the form of useless chips. By sawing the part, not only were labor savings effected, but the two cutaway portions, worth $320, were available to make into other parts.

Because of the qualifying aspects of toothless, low speed sawing, Ryan does not view it as a replacement for conventional sawing tasks. With between 40 and 50 band saws in operation in the plant, we feel that a limited number can be adapted to this method where the specific gauges and production needs indicate its usefulness.

Ideas By F. E. Riley . . . through page 18-22

Handles for Solvent or Oil Containers

SPECIAL lubricating oils and other industrial liquids are often supplied in rectangular containers holding one gallon. The containers measure 6½ by 4¼ in. in cross section with generously rounded corners, and to manipulate a container with these proportions usually requires the use of two hands. Owing to the smooth exterior of the container, controlling the flow of the liquid from the small spout is not easy and spillage inevitably results when a small can is being filled.

Handling of these containers has been eased considerably by the fitting of a handle, as shown in the illustration. The handle can be fitted to any of the four sides of the container for convenience in arranging the spout for easy pouring. By means of the handle, the container can be manipulated with one hand while the other is used for holding the vessel which requires filling.

There are various methods suitable for constructing the handle. It may comprise a strip of steel bent to the shape shown with a bent-over tongue of metal at one end for engaging the lip which runs around each end of the container. The other end has a detachable portion also provided with a lip and means for pulling the two parts together so that the complete handle grips firmly the length of the container; this clamping means can comprise an upstanding lug in both the handle and second piece, with a nut and bolt passing through both to pull them together.

Ever try to pour solvent or lube oil from a rectangular gallon can without spilling it? It can be done, but it is much easier with the handle shown

The construction shown in the illustration is slightly more elaborate and consists of three separate pieces — a handle and two end clips. The clips are bent up from sheet metal and have elongated slots for engagement with small nuts and bolts which hold them to the handle. Each clip is adjustable on the handle so that slight variations in container sizes can be accommodated. Having both clips adjustable enables the position of the handle to be altered in relation to the center of gravity of the container. Actually, this latter refinement has proved superfluous.

It has been found during use that the handle can be detached from a container by simply pushing down hard to compress the side and this shortening of the container length allows the handle to be sprung off. A similar procedure enables it to be sprung on to another container of the same size, without the need for adjusting the clips. There is, however, no danger of the handle coming off during lifting of the container as it is then in a state of tension and is gripping the load firmly.

Wastage of oils has been reduced, more convenient handling of the containers, and greater cleanliness has resulted from the adoption of this handle.

Rough Hexagons Can Be Easily Machined

EXTENSIONS are often needed for increasing the effective length of tubular box wrenches so that remotely placed nuts and bolt-heads can be reached. The extension normally consists of a piece of cylindrical rod with a male hexagon machined on one end for fitting into one end of the tubular wrench. The hexagon on the extension should be a reasonably close fit so that it stays in engagement with the hole in the wrench.

It is difficult to file an accurate hexagon on the end of a rod and setting up a milling machine for doing the job is not usually worth the trouble and time. A simple method of machining hexagons with accurately spaced flats is as follows.

The extension rod can be made from a scrap high-tensile steel bolt with an outside diameter equal to that of the box wrench. A nut is fitted on the thread of the bolt and should be a fairly tight fit so that it will not turn on the thread with normal handling. If an ordinary nut which is sufficiently tight cannot be obtained, then one of the new lock nuts with a fibre or nylon insert can be used. An alternative is to saw through the wall of a common nut and to squeeze

Run tight-fitting nut on threaded stock (or a bolt in this case), then grind flats in light passes. If nut is loose, hacksaw through one flat to hole and squeeze together on thread. Grind to a fit

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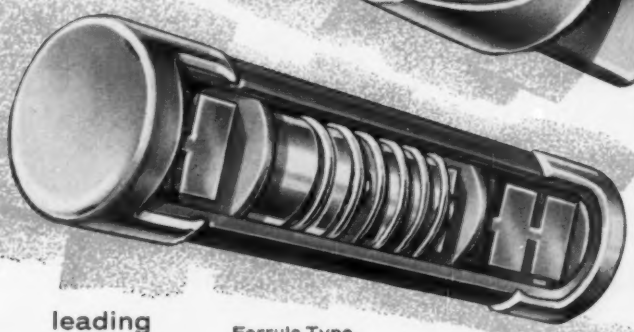

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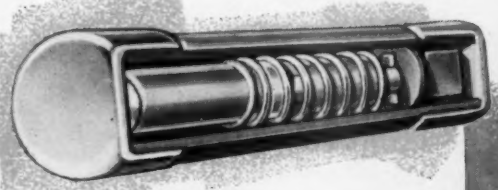

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it on to the bolt.

The flats of the hexagon can be ground on the end of the bolt by the method shown in the illustration. The nut bears on the grinding wheel rest with one of its flats in contact therewith and the bolt end is presented to the side face of the revolving grinding wheel. If the bolt is turned so that the nut flats bear on the wheel rest in succession, a series of equally-spaced flats will be ground on the end.

The successive cuts of the grinding wheel should be light so that the width of the flats can be closely controlled. It is fairly easy to rough out the hexagon to size by watching the grooves in the thread which become progressively narrower as metal is ground away from them. When final size is approached, it is better to give the hexagon a slight taper from front to back and then to try the small end for size in the socket wrench as grinding continues. When the hexagon will enter for half its length, grinding can cease and the extension driven lightly into the hexagon hole in the wrench; the two will then be firmly secured together, but can be separated easily, if necessary.

If the bolt used to make the extension has a hexagon head, this can be used for turning with another wrench. If space is restricted and the large bolt head would get in the way of things, it can be cut off and a cross hole drilled for a suitable rod which can be used for turning.

Magnet Helps in Screw Sorting, Cleaning of Machines

ASSORTED nuts, bolts and washers are collected by all maintenance mechanics and usually stored in one can.

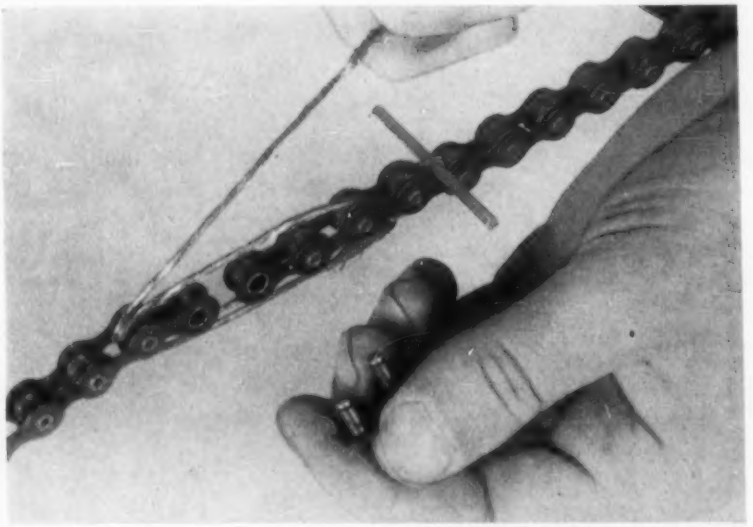
When a screw is needed, the can is tipped on to the bench top and the heap picked over for something of the desired size and shape. After this has been located, the next job is to return the heap to the container by picking them up with the fingers.

A much quicker job will be done by using a strong permanent magnet in combination with an aluminum shield or casing. In the example illustrated, the aluminum casing is a discarded container in which is inserted a permanent magnet of the button type. These magnets have an axially placed hole in which can be fitted a non-ferrous screw and nut to form a suitable handle.

With the magnet shielded by the aluminum container, it is held over the heap from which it will pick up a substantial bundle of the ferrous screws and nuts. The load is then poised over the screw container and a slight pull exerted on the shield will pull it clear of the magnetic poles and the load drops. The movements can be performed rapidly and the heap of screws illustrated can be sorted and transferred back to the container in about one-third the time needed for hand picking.

Another use for the shielded button magnet is in the clearing up of shavings from small machines and hard-to-reach places. Because of the shield, the load can be picked up and disposed of much more quickly than if the magnet were used in an unprotected condition.

Fig. 1. Ferrous screws, nuts, bolts and washers are easily separated from a pile with this magnet, then dumped into container by lifting magnet out of shield. Magnet can be fitted with handle to get chips from hard-to-reach corners in machines



The simpler the idea, the more likely it is to be used—such as this method of joining roller driving chain

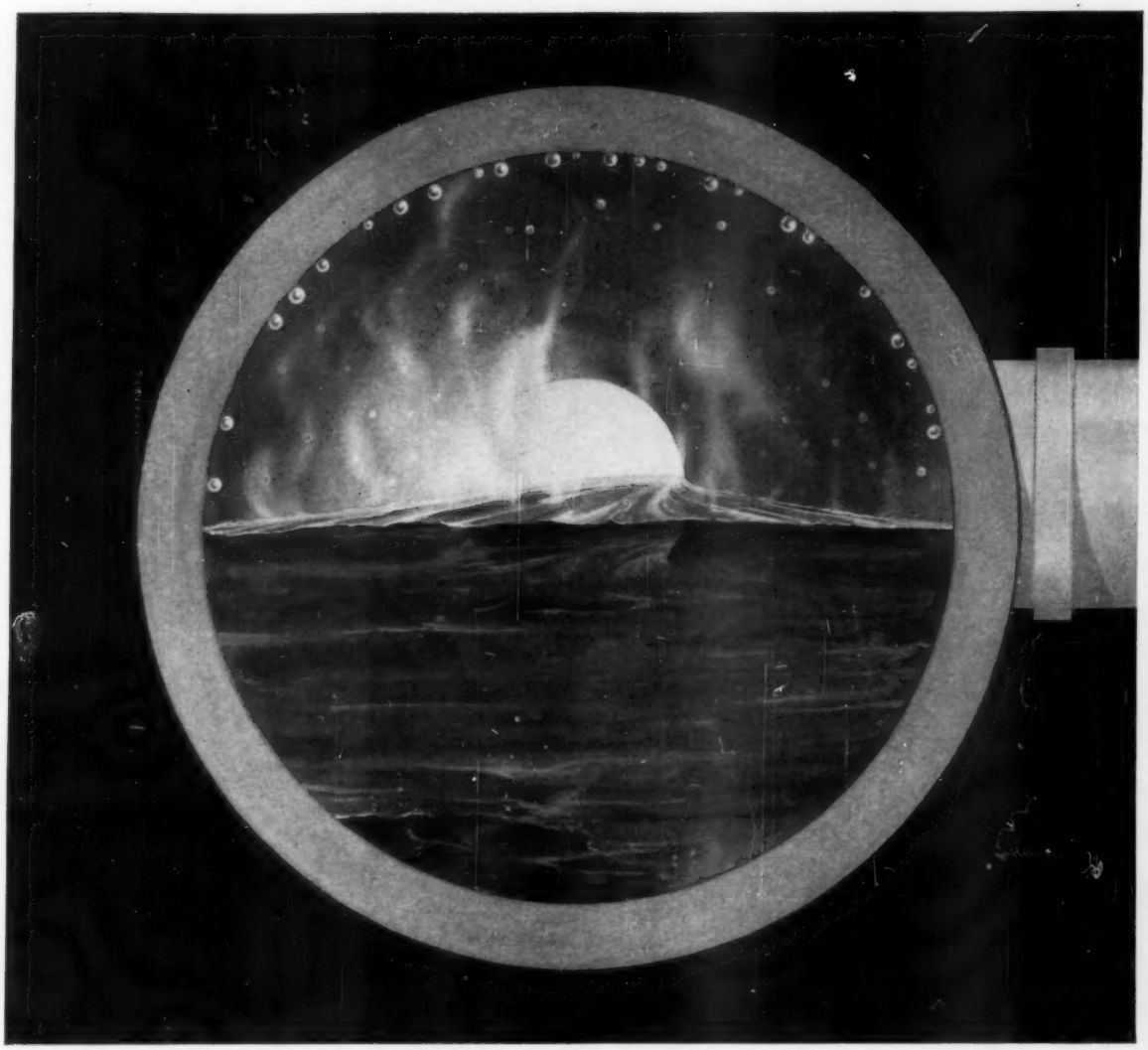
Transmission Chain-Joining Tool

By F. E. RILEY

JOINING the ends of a roller driving chain, or any other chain, is usually a two-man job. One man holds the chain ends together while the other inserts the joining link or pins. When the chain is a heavy type the task for the man holding the two ends is made very arduous, particularly if the sprockets and shafts revolve easily. If one end of the chain is allowed to slip out of the hand, the free sprockets revolve under the weight of the chain which will then roll off them.

Chain joining can become a one-man task if the gadget illustrated in the photograph is adopted. It consists of a length of stranded metal cable and a pair of pins which can be inserted into loops at the ends. In use, one end of the cable is threaded through the gap between a pair of adjacent rollers and the pin is inserted into the loop at the cable end so as to span the links. The cable is then threaded through a link in the opposite end of the chain. The wire can span the gap between the chain ends several times and the greater the number of spans, the greater the pull exerted to bring the two ends of the chain together. The free end of the cable can be pulled conveniently with one hand holding a pin passing through the second loop.

With one hand pulling the chain ends together, the other hand can be used for inserting the pin or connecting link. An advantage of the device is that the loops of cable spanning the gap between the chain ends automatically aligns the two end links. Pulling the two ends of a roller chain together is fairly simple because the rollers act as miniature pulleys for the cable. Other types of chain, without rollers, can be joined by adopting a similar procedure, although the pull exerted will need to be strong owing to the lack of rolling where the cable turns in the links.



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Hose Clips Find Other, Handy Uses

HOSE CLIPS of the worm drive type can now be obtained for gripping a wide range of diameters. The diameter range of each individual clip is also sufficiently wide to make it applicable to do work other than clamping rubber hoses to metal pipes.

One useful application of a hose clip to lathe work is illustrated in Fig. 1. The clip is being used as a driving dog, a job for which it is particularly suitable. Owing to the clip's small size, or lack of projections, it can be used for driving work up to the maximum diameter of which the lathe is capable; there are no projecting arms to catch on the lathe bed or prove dangerous to the machine operator.

Another advantage of using a hose clip as a driving dog is the very firm hold which can be obtained on soft work pieces, without marring the surface finish. In the illustration, the hose clip is gripping the finished copper commutator of a small motor which has suffered no damage. Driving the hose clip and its work is accomplished by bolting a driving peg to the lathe face plate as shown.

Hose clips permit a new machining technique to be evolved when used in the manner illustrated in Fig. 2. When numerous pins are to be faced off to identical lengths it is usual to grip each one individually in a lathe chuck and to face it off with a fixed turning tool. This procedure can prove very tedious and time consuming.

By using a hose clip, a batch of pins can be bound together to form a firm bundle and this, gripped in the lathe chuck, enables the whole lot to be faced off at one cut. When the pins are long enough, it is advisable to use two hose clips to make up the bundle since there is a tendency for the bundle to swivel out of square, in some cases; this would result in the machined ends being out of square with the axes of the pins and alter overall length.

Fig. 1. Hose clip used as a driving dog on a lathe gives a good grip on soft pieces without marring

Fig. 2. Facing and cutting batches of pins to the exact same length is done by bundling with clamps

Quick-Settling Plumb Bob Uses Magnetic Damping

PLUMB BOBS with their attendant lines are used extensively in the erection of large machines. One technique is to use wire instead of string for suspending the plumb bob and to make accurate measurements horizontally between the wire and a vertical face on the machine structure. Traditionally, the plumb bob is made as heavy as possible and has a pointer which is concentric with the axis of the suspending wire or string.

For use where the structure being worked on is all metal, a permanent magnet plumb bob can be employed. Experiments have shown that such a bob will come to rest very rapidly and will remain stationary. The simple experiments with such a magnetic plumb bob suspended over a cast iron surface from a cord 2 ft long are interesting. Given an initial oscillation of 3 in. either side of a marked line on the surface, the plumb bob came to rest in one minute. A non-magnetic plumb bob of equal weight was still oscillating at the end of five minutes.

The heart of the magnetically damped plumb bob is a commercial type of pot magnet which is shown in section in Fig. 1. The pot magnet has a cylindrical core in the form of a permanent magnet and is enclosed by an annular ring of non-ferrous alloy. The outer casing of the magnet is in the form of a mild steel cylindrical pot with a threaded hole at its upper end. The casing can be machined concentrically with the magnetic core and with the hole in the end. Because of the density of the magnetic core, a pot magnet 1 in. in diameter and 1 in. long weighs about 4 oz, which is sufficiently heavy for most general plumb line work.

When the plumb line is to be used as a reference, the magnetic plumb bob can be used in the manner shown in Fig. 1. The only addition to the magnet is a threaded cap on top to act as an anchor for the cord or wire.

The magnetic damping effect is more efficient if the air gap between the lower face of the magnet and the metal work surface is at a minimum. Magnetic pull of the plumb bob is very powerful with a small air gap and a string will be stretched, making maintenance of the air gap difficult. For this reason a steel wire is better.

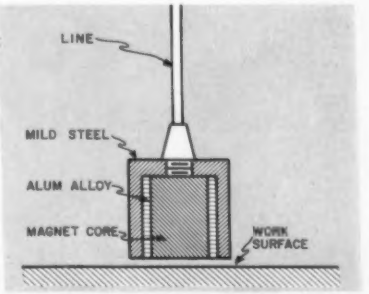

Fig. 1. When line itself is to be used for reference, blunt-ended bob can be used (shown). The permanent magnet's pull adds 2 lb to cord tension

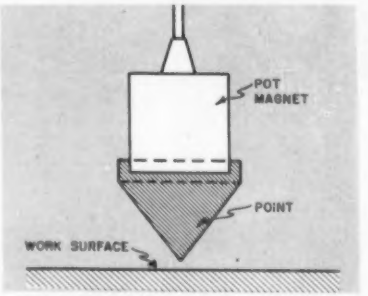

Fig. 2. Mild steel cone with socket in top makes bob easy to center on a mark. No threads or fasteners are needed to hold cone; the magnet does it

The powerful pull of the pot magnet has the effect of increasing the apparent weight of the plumb bob. For instance, the magnet described will lift a weight of about 2 lb when in metallic contact with it. With an air gap of $\frac{1}{16}$ in. the pull exceeds 6 oz.

If the plumb bob is to be aligned with a mark on a metal surface, a point must be provided in the manner shown in Fig. 2. The point comprises a turned mild steel cone with a recess at one end for locating on the machined exterior of the magnet casing.

OBITUARIES

Christian Steenstrup

CHRISTIAN STEENSTRUP, retired General Electric refrigeration consultant, who developed the hermetically sealed refrigeration unit and fathered the suggestion award system in American industry, died recently at his home. He was nearly 82.

One of the nation's leading inventors, with 128 patents to his credit, Mr. Steenstrup retired from General Electric on September 1, 1945, after 44 years of service during which he headed the company's refrigeration organization and fostered a suggestion award plan which has paid out more than $6 million to G-E employees.

He held the Modern Pioneer Award of the National Association of Manufacturers for his hermetically sealed refrigeration unit which brought refrigerators within pocketbook reach of the public and twice received G-E's coveted Coffin Award. One award was for his refrigeration work and another for development of a method of hydrogen copper brazing which made that process practical for commercial work.

Place Portable Grounds to Protect Linemen

continued from page 84

guy anchor or a driven or augur type ground rod. In addition, the connecting cables that are to go to the line conductors could be attached to the cluster block on the potential band. When the outage is taken, the lineman can then "buzz" his lines, pick up the conductor attachment ends of the connecting cables with his hot stick and attach them to the line conductors. The zone of the pole above the potential band has in this way been made an "equipotential zone." In case of fault, now, the lineman's working area — things he touches with his hands and his feet — has been brought as nearly as possible to an area of zero potential difference. This method is shown in Fig. 5.

It is necessary to keep two points clearly in mind whichever of the two above outlined methods of working on wood pole lines is selected:

1. In a multipoled structure, all poles composing the structure must have the bare copper wires installed along them if that is the method being followed, or the potential bands placed around them, if the latter method is being employed. This must be done irrespective of whether workmen are

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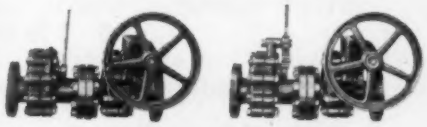
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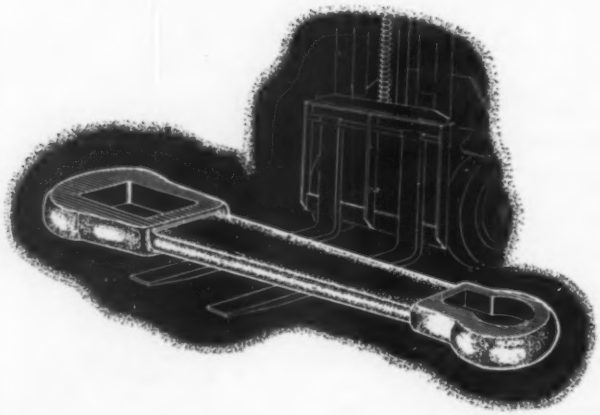

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Place Portable Grounds to Protect Linemen

continued from page 115

to climb all poles of the structure or not.

2. All guys will have to be connected to the bare wires installed along the poles or to the pole band or bands. This latter requirement is not as onerous as it sounds since advantage may safely be taken of the connecting together of many guys either at the same anchor rods or at the same through bolts on the poles. By these means or by separate connections, however, all guys must be connected to the bare wire along the pole or the pole bands as the case may be. In either case, it would not matter too much whether attachments to guys were above or below insulators, if any, except of course, that if a guy anchor is utilized for a ground the attachment should be made below any insulator.

The practical applications of this method of protection for wood poles work remain to be worked out, but the authors believe that the principles above described if followed will serve to afford linemen real protection in place of the somewhat illusory safety afforded by all too many of their existing procedures.

Stop Worrying about Fuel

continued from page 73

The question of whether the coal man or the boiler man should undertake fitting the engineered product into a system incorporating coal and ash handling facilities so as to give the small customer "automation" is still a moot question. Even though solved in an engineering way, there still remains the problem of the customer and his consultant with their personal wishes so well expressed by the following quotation: ". . . efforts to purchase only the assembled water-tube package boiler to be trimmed with auxiliaries not of the manufacturer's choosing have been made. . . . Such efforts defeat endeavors by a manufacturer to produce a guaranteed product. How best to handle this problem and yet not discriminate has no simple solution. . . .

Consulting engineers preparing specifications could indicate that only the complete package, as produced by a manufacturer, who shall be named by a bidder, will be accepted. It would also be advisable to demand that the package as produced shall be fire tested, at point of manufacturer, under conditions as specified, before shipping. This procedure would provide a guarantee of functional performance not otherwise possible. This practice would discourage, if not eliminate, substitution of unrelated, and in some cases, inferior auxiliary equipment."

POWER ENGINEERING 1955 YEARLY INDEX

IN THIS issue are bound the 1955 alphabetical and subject indexes of POWER ENGINEERING.

However, for those libraries and individuals who wish to bind the index with the 1955 volume, separate copies of the index are available. If you want such a separate copy, write the Editor.

How Much Does a Ton of Coal Weigh?

continued from page 88

to hold the water by capillary attraction. The fine coals take on weight because they have more surface area, the surfaces are closer together and aid capillary holding of the water, smaller voids that can fill and contain the water, and so on. Once wet, as by washing, these fine coals retain this water tenaciously, and thermal drying is required to remove it.

Figure 5 shows the increase in weight per ton of coal for various moisture percentages. It is apparent that much can be paid for water if the track scales weigh the coal wet. It is for this reason that many plants purchase their coal on a dry basis, since rain in transit adds moisture beyond the control of the producer, shipper, or buyer. Sampling and weighing should take place at the same time, at the same location.

It is a moot question whether fine coals, especially carbon sizes, gather in much moisture due to rain or snow on the road. Without a wetting agent, fine coal may actually repel water. High moisture in carbon sizes probably gets into the mass of coal before the coal gets into the car. The moisture then stays with the coal, without much drainage, for some distance. River barges of coal can actually lose considerable moisture on long hauls in hot, dry, sunny weather because of the relatively large surface area exposed to the atmosphere, compared to the total volume of the load. Evaporation may become noticeable in gaging the barges at both ends of the trip, or in the analyses of the samples taken at these points. Fine coals that have been stored for a long period of time become heavier because of increased moisture.

Many transportation companies realize that some coals lose moisture in transit from the time the coal leaves the mine tipple, where it has been weighed, until it reaches its destination. Drainage from cars or evaporation from the large surface of open barges which have been weighed or gaged at their loading source, diminish in their actual measured weight at destination. In certain areas where the moisture in the original

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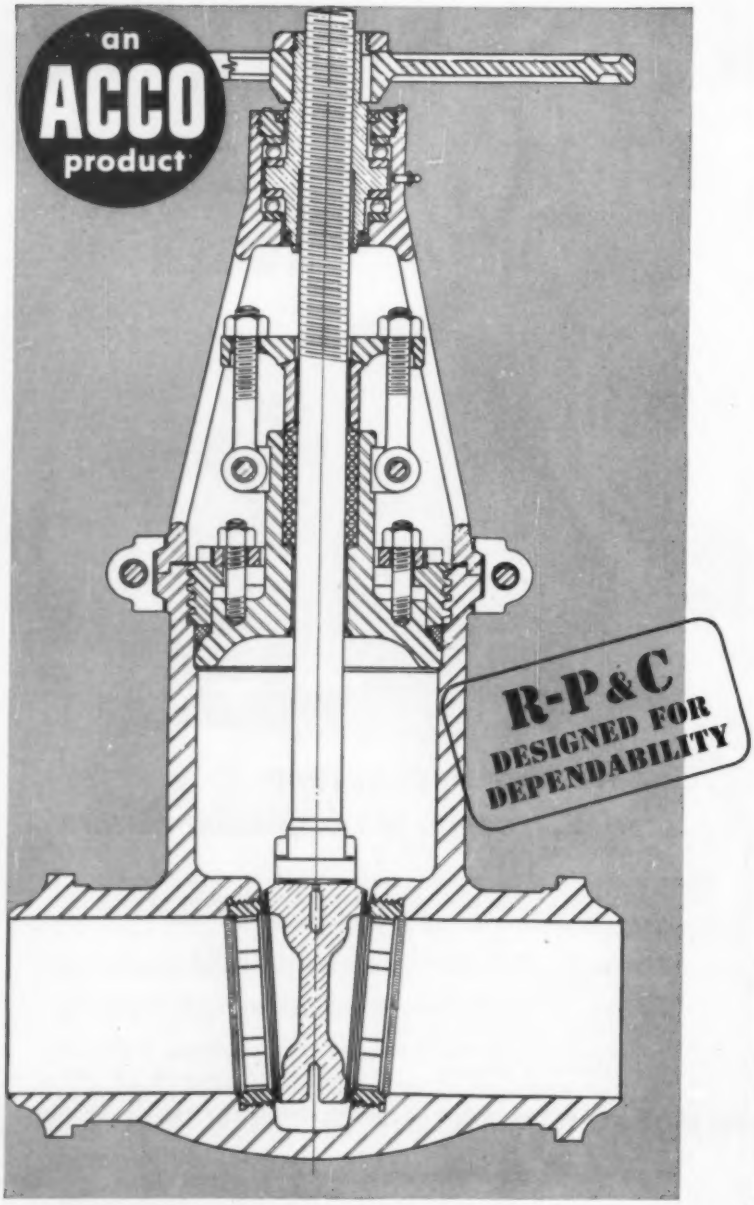

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How Much Does a Ton of Coal Weigh?

continued from page 117

coals is high, especially after washing and preparation, weight tolerances are allowed in the initial weighing as an adjustment to meet the weight at destination. The finer the coal, the greater the moisture retention, and the greater the tolerance allowance. Allowances that have been made on this account are shown in Table II.

Figure 6 shows the combined effects of ash and moisture in the coal as it affects the weights of a car of 50-ton capacity. Other sizes of cars would show proportional differences in the weights.

Table III shows the effects of the conditions discussed in this article on two 50-ton cars, one loaded with egg, and the other with carbon-size coals; both coals are from the same source and cars are loaded to normal capacity.

It has been the purpose of this article to point out the variation in loading that can be expected with different types, sizes, and analyses of coals. An understanding of these conditions is useful to all those who handle coal in the production of power. Although the fuel engineer is generally more interested in the burning characteristics of coal, the coal buyer in prices and deliveries, and the plant superintendent in costs and possible difficulties, all of these men run into the weight problem at one time or another.

Even the design engineer looks at weights early in the game; his is the responsibility for the size and strength of coal storage and handling facilities. But after these are built, the loading, unloading, and billings are thought of only in terms of cars, barges, compartments, or trucks. Volumes and densities are forgotten. However, at inventory time, volume and density again assume great importance when the surveyors and accountants set about determining exactly how much each ton of coal on hand actually weighs.

What's Being Done to Prevent Another Turbine Failure

continued from page 89

methods, and improvement in inspection techniques.

† The Work of the Task Force on Brittle Failure of Steel Forgings

In January 1955, the American Society of Testing Materials appointed a Task Force to study the whole question of brittle fracture in steel forgings. This Task Force comprises representatives of eight companies — three manufacturers of electrical equipment and five manufacturers of large forgings for turbines and generators, representing all the

makers and users of large forgings of this type in the United States.

The work of the Task Force falls under three main headings:

1. To discover a test to determine whether or not a steel is subject to brittle failure.
2. To make rotors less susceptible to brittle failure.
   - A. By heat treatments.
   - B. By chemistry.
   - C. By vacuum pouring techniques.
3. To develop methods of inspection and interpretation to avoid brittle failure of forgings in service.

It is important to realize that both the electrical manufacturers and the steel companies have, through the years, continually devoted intensive effort to making better and safer forgings, and the large number of successful units in service today substantiates this. Furthermore the techniques of manufacture and inspection have been subject to constant review and have been changed and improved with the growth of metallurgical and engineering knowledge and experience. The work of the Task Force is the correlation of thinking and experience to the end that the development may be more rapid.

References

* ASME Paper No. 55-A-208, "Report of the investigation of two generator roter fractures" by C. Shabtach, E. L. Fogleman, A. W. Rankin, and D. H. Winne, of the Large Steam Turbine Generator Department, General Electric Co.; Paper No. 55-A-210, "Report of the investigation of the turbine wheel fracture at Tanners Creek" by A. W. Rankin and B. R. Seguin, also of the Large Steam Turbine Generator Department, General Electric Co.; Paper No. 55-A-172, "Investigation of large steam-turbine spindle failure" by H. D. Emmert, Asst. Chief Engineer, Steam Turbine Department, Allis-Chalmers Mfg. Co.

** ASME Paper No. 55-A-194, "Acceptance guides for ultrasonic inspection of large rotor forgings" by A. W. Rankin and C. D. Moriarty, of the Large Steam Turbine Generator Department, General Electric Co.

† ASME Paper No. 55-A-209, "The work of the task group on brittle failure of steel forgings" by A. O. Schaefer, Vice President and Executive Assistant, The Midvale Company, Philadelphia, Pa.

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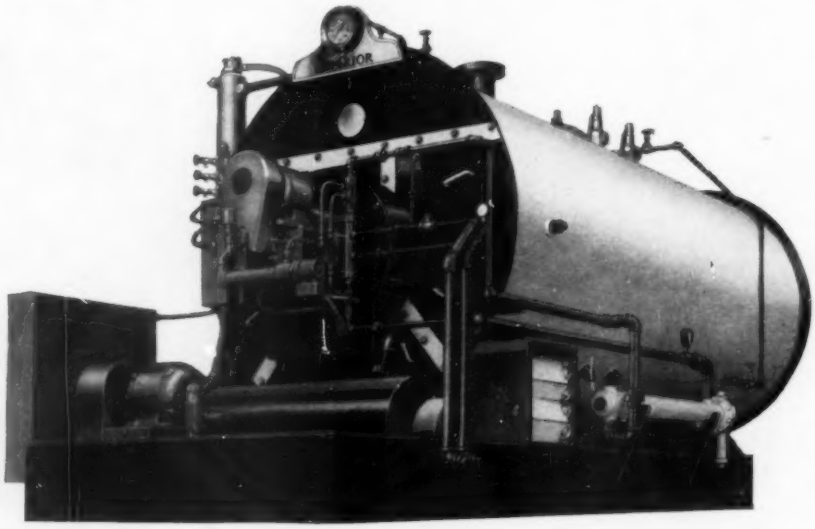

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201 **Packaged Boilers** — This 16-pp illustrated catalog describes manufacturer's new Type VP package boiler. Following a section of background information is an outline of the principal design features of these boilers, which are shop assembled and provide steam capacities from 4000 to 30,000 lb per hour. Space requirements are shown in a table along with typical specifications. Also described in detail is the complete control system. Combustion Engineering, Inc.

202 **Standard Boilers** — Eight-pp Bulletin WT-8 describes company's "S" series of boilers with capacities ranging from 10,800 to 50,000 lb. Lists data and specifications on each of the models and sizes, and discusses general design features and special "S" type construction features. Wm. Bros. Boiler & Mfg. Co.

203 **Automatic Boilers** — This bulletin describes 17 sizes of Powermaster packaged automatic boilers from 15 through 500 hp for steam process, steam and hot water heating service. Lists such advantages as three-pass design, forced draft and automatic controls. Describes firing equipment for light and heavy oils, gas; shows various fuel firing arrangements. Orr & Sembower, Inc.

204 **Automatic Boilers** — Bulletin BE-4 describes operation and advantages of Continental automatic boiler's spinning gas technique — a method of obtaining maximum heat transfer with a simplified design. Shows cutaway view of boiler construction; illustrates hinged doors and method of injecting air through static, turbine-like vanes into burner. Boiler Engineering & Supply Co., Inc.

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205 **Self-Contained Boilers** — Bulletin AD-144 reviews company's new CB boilers. Illustrations include installations, demonstrations. Engineering articles are featured covering such subjects as low noise level. Cleaver-Brooks Co.

206 **Steam Generators** — Illustrated Bulletin SB43, 20 pp, describes company's VL factory assembled generators combining 2-drum water-tube boiler, integral water cooled furnace, brick work, insulation and steel casing. A large cutaway illustration shows design details, and gas travel. Erie City Iron Works.

207 **Compact Generator** — This bulletin describes a packaged water tube

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generator, company's Type DK, available in units for 8400 to 45,000 lb of steam per hour. Gives features, size and capacity data on these boilers which are designed to require less space than many water tube units. E. Keeler Co.

208 Steam Generator — This manufacturer's new Type D steam generator, a packaged unit for pressure firing with gas, oils or combination of fuels, is described in an 8-pp catalog. Gives complete data and dimensions on this water tube generator which is available in 17 sizes with capacities from 8000 to 40,000 lb of steam per hour. Fully illustrated, booklet explains economical steam production. Superior Combustion Industries, Inc.

BURNERS

210 Automatic Burner — Bulletin 420 contains approximately 30 pp of engineering data on a new burner unit for gas, oil or combination firing and sized for capacities to 42,000 lb of steam per hour. Separate sections of this looseleaf manual are devoted to photos and discussion of special features of the burner, general specifications, parts list, wiring and piping diagrams, explanation of operating sequence, and performance data. Available to qualified power engineers, please state your job title when requesting this bulletin. Peabody Engineering Corp.

211 Oil and Gas Burners — Bulletin OB-53, 28 pp, gives principles of selection and application of oil or gas burners, or a combination of both for standard and wide capacity range operation, together with air registers and fuel oil heating and pumping sets. Conversion table shows approximate relationships between quantity of oil burned, boiler capacity and air required for combustion. The Engineer Co.

212 Steam Atomizing Oil Burners — Sixteen-pp illustrated Bulletin 21 describes steam atomizing oil burners and auxiliary equipment for use with heavy oil or tar in boilers, stills, dryers and other furnaces, where steam or compressed air is available for atomizing the oil. Includes information on furnace design and construction. National Airoil Burner Co., Inc.

COAL, ASH HANDLING

213 Burning Bituminous Coal — This 24-pp illustrated booklet is a compilation of numerous actual case histories of industrial plants and institutions which burn bituminous coal "the modern way." Stressing operating economy achieved, these case histories show problems overcome, equipment used, and savings realized. Bituminous Coal Institute.

214 Spreader Stoker — Sixteen-pp Bulletin 800 describes manufacturer's Type C-C RotoStoker, a relatively small spreader stoker offering continuous cleaning and ash discharge advantages of larger units, without need of a basement for ash-removal. Explains this and other operational advantages of the stoker, which is adapted to modern steam boilers with output capacities of about 5000 to 75,000 lbs of steam per hour. Detroit Stoker Co.

215 Coal Crusher — Company's WC and WS series rolling ring coal crushers are described in Bulletin 154. Emphasizes special construction elements that mean greater coal reduction at lower operating costs. Cross section illustration shows both

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feeding and crushing action incorporated and tables give capacities, speeds, and dimensions. American Pulverizer Co.

TUBING AND ACCESSORIES

216 Rotary Tube Cleaners — Bulletin R-105 presents air and water driven rotary tube cleaners and cleaner accessories. Illustrates several models and heads. Roto Div., Elliott Co.

217 Nickel Pipe and Tubes — Bulletin T-17 is a 28-pp technical bulletin on the fabrication and design of nickel and high nickel alloy pipe and tubing, illustrated throughout by drawings and photos. Presents tables on mechanical and physical properties, ASME code requirements, recommended welding procedures. The International Nickel Co., Inc.

218 Life Extension for Condenser Tubes — The 32-pp current edition of this booklet reports on research into the causes of corrosion and means of combating them, as well as the choice of condenser tube materials. Points out that Admiralty metal, long a standard for power plant condenser tubes, works satisfactorily in most installations, but other alloys may be necessary in some circumstances. Revere Copper and Brass, Inc.

219 Tube Cleaners — Catalog 76-A provides 48 pp of information on manufacturer's line of tube cleaners. Following equipment selection and operating hints, this practical catalog describes and pictures cutter heads and drill heads, brushes, and motors, giving sizes, application information. Air valves, hose, lubricators are described. Thomas C. Wilson, Inc.

INSTRUMENTS AND CONTROLS

221 Metering and Control Equipment — Sixteen-pp Bulletin 18 is a comprehensive catalog offering information on company's meters, control equipment and engineering services. It is written for engineers in power plants, public utilities and process plants. Fifteen measured variables common to power and process operations form the index for selecting appropriate equipment. Bailey Meter Co.

222 Boiler Feed Control — Bulletin 1003, a 12-pp catalog on boiler feed regulators, is illustrated with large application photos and detailed schematic drawings and charts. Relay and direct operation are covered. Case studies of representative boiler loads are presented to show stability of the Flowmatics in controlling feedwater automatically. Copes-Vulcan Div., Continental Foundry & Machine Co.

223 Power Plant Instruments — Publication 55-605-83, 24 pp, presents well-organized data on manufacturer's line of boiler plant instruments and control systems. Generously illustrated with photos and schematic drawings, booklet describes combustion guides; draft gages; flow, level, temperature and pressure instruments; combustion control systems; and panels. Instrumentation installations at eight plants are charted as to problems involved and results. The Hays Corp.

224 Indicating Flow Meter — Bulletin 18-A, 22 pp, discusses advantages, construction and operation of company's Type H indicating flow meter. Presents technical data on the principles and theory of fluid measurement and discusses orifice type meters and orifice meter principles.

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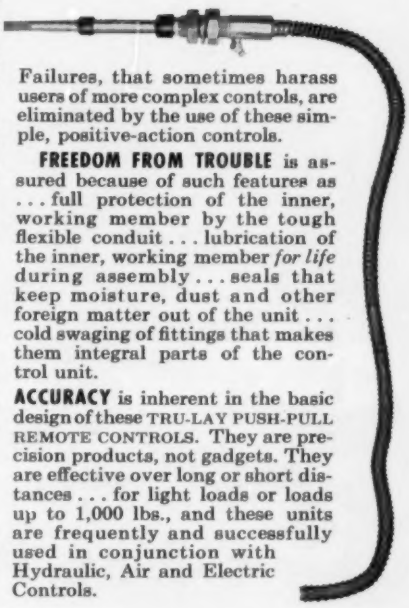

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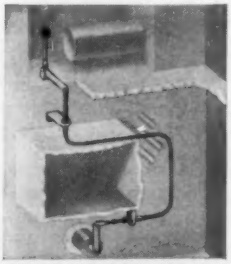

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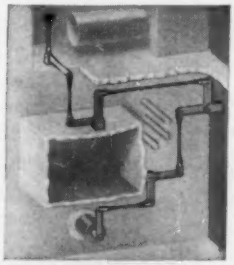

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Offers examples of flow rate calculations. Schematic drawings and diagrams, tabulated technical data and specifications are included. The Meriam Instrument Co.

225 Instruments, Controls — Condensed Catalog 1537 offers brief application information on manufacturer's line of instruments. Fully illustrated, covers draft and pressure instruments, flow meters, liquid levels and pressure gages, CO_2 meters, pneumatic transmitters, positioning operators, temperature instruments, boiler feedwater controls, others. Includes references to detailed literature on each type of equipment. Republic Flow Meters Co.

226 Sampling System — A newly developed system for continuous sampling and oxygen measurement of combustion processes is described in Bulletin 703. Points out advantages of system and diagrams component parts. Selection of sampling tube and gas selector units is discussed. Arnold O. Beckman, Inc.

227 Easy Reading Gage — An all-hydrostatic remote reading gage for boiler water and other liquid levels is described in Catalog 500, Section CO. Pictures improved visibility, other advantages offered by this gage, explains operation. The Reliance Gauge Column Co.

228 Muscles For Industry — Pneumatic power positioners to provide the "muscles" for thousands of exacting control loads are described in this packet of specification sheets, Bulletin TP-MF1. Individual sheets describe performance and construction specifications for standard positioner models, designed for applications where thrust and positioning accuracy requirements are severe — to control flow, pressure, temperature, or level by operating valves, gates, or dampers. Covers positioner cylinder sizes from 4 by 5 in. to 12 by 48 in. Hagan Corp.

229 Steam Calorimeter — This bulletin discusses an improved U-path calorimeter combining a throttling, separating and re-evaporating calorimeter in a single chamber. Explains construction and operation of unit. Ellison Draft Gage Co., Inc.

230 For Feedwater Analysis — Bulletin 148BP contains a technical discussion of manufacturer's analyzers for determination of dissolved oxygen and hydrogen in feedwater. Discusses both O_2 and H units as to function, ranges, accuracy. Cambridge Instrument Co., Inc.

ELECTRICAL EQUIPMENT

232 Motor-Generator Reference Book — Publication 51R7933 is a 50-pp booklet compiled to assist in the selection of motive power to handle most industrial applications. Neither textbook nor ordering catalog, this book provides a brief outline of the various types of motors, generators and motor-generator sets, telling their applications and operating requirements. Booklet is generously illustrated and includes performance data, ratings, information on methods of speed control. Allis-Chalmers Mfg. Co.

233 Insulation Temperature-Resistance — Technical Publication 21T4, 16 pp, is an article on temperature-resistance characteristics of electrical insulation. Complete with tables and graphs, gives general information on variations in temperature characteristics, composite nature of electrical insulation, and practicability of temperature compensation. Other chap

ters deal with determining insulation constants for temperature correction factors, and a practical method of obtaining insulation temperature. James G. Biddle Co.

234 The Answers on Wiring — "20 Questions and 20 Answers on Safety m.i. Wiring" describes and illustrates characteristics and advantages of this new wiring system. A complete table of types, sizes, weights and lengths, as well as a partial list of users included. General Cable Corp.

235 High-Power Batteries — Bulletin CP-538/55 covers company's line of Hi-Power batteries for use in the control, switchgear, emergency lighting and auxiliary power fields. Includes data on battery ratings and capacities, details of design and construction, dimensions, weights and types of containers. C & D Batteries, Inc.

Postage-free cards for ordering catalogs are on page 120. You may also use the cards to order literature mentioned in the ads.

236 High-Capacity Fuses — Form HCS, 6 pp, describes fuses of unlimited interrupting capacity on voltages to 600, designed to afford protection for loads of 600 to 5000 amp. Includes test data, charts on opening time, current limiting effect. Bussmann Mfg. Co.

PUMPS, COMPRESSORS

237 Boiler Feed Pump — A barrel-type boiler feed pump for high pressure, high temperature service and designed to go on the line quickly without preliminary warm-up is the subject of 12-pp Bulletin 1525. De Laval Steam Turbine Co.

238 Controlled Volume Pumps — Bulletin 953, 24 pp, describes and illustrates use of controlled volume pumps in industrial water treating systems. Construction and operation features are described, capacity-pressure ranges and speed and stroke length adjustments are charted. Typical chemical feed and water treating systems are presented through text and diagrams; and an analysis of boiler water treating systems, cooling water treating problems, and systems for waste and sanitary water treatment are included. Milton Roy Co.

239 Balance Opposed Compressors — Engineering data on company's balanced opposed compressors, 3000 to 10,000 hp (top range in tandem arrangement) are contained in 36-pp Bulletin L-679-B1. Presents information on operation, drives, design features, running gear, lubrication, valve action, capacity control, coolers and accessories. A chart listing approximate dimensions is included, along with photos of compressor installations. Worthington Corp.

VALVES, TRAPS, PIPING AND ACCESSORIES

241 Check Valves — Twenty-pp Catalog 30 presents company's line of tilting-disc check valves made in iron, bronze and steel for working pressures to 3000 psi. Explains operating principles of tilting disc construction, discusses closing without slam, reduced loss of head, other advantages. Includes construction details, sizes. The Chapman Valve Mfg. Co.

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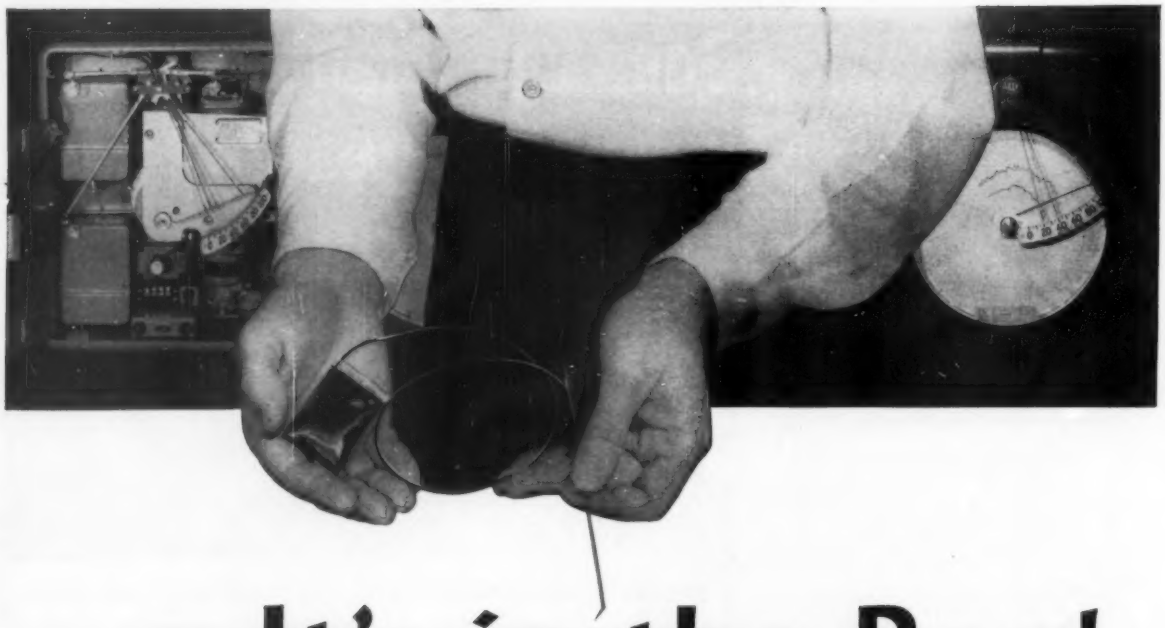

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242 Lubricated Plug Valves — Revised Catalog PV-2, 12 pp, presents steel and semi-steel valves designed to offer quick shut-off of erosive or corrosive fluids. Explains advantages of the lubricated tapered plug design of these valves and pictures single gland, screwed gland, and bolted gland types. Also shows accessories. The William Powell Co.

243 Blow-Off Valves — Bulletin B-426, 20 pp, on blow-off valves for boiler pressures up to 400 lb wsp, contains installation recommendations, construction information on Yarway Seatless and double-tightening blow-off valves. Gives full ordering data. Yarnall-Waring Co.

244 Choosing the Right Valve — Presenting valve selection as a matter of matching the valve's service characteristics with service requirements of the job, this practical 20-pp booklet explains and illustrates basic design features of gate, globe and check valves. It tells, in non-technical language, how each of these valve types works, and where it is suited for use. Disc, stem connection, bonnet and bonnet-joint characteristics are also discussed and the importance of stem operation is treated. Crane Co.

245 Valve Chart — Form 194, 24 pp, is a valve comparison chart, listing valve figure numbers of 15 major manufacturers and the OIC equivalent valve figure numbers. Compares variety of valves in ferrous and non-ferrous materials, describes different valve lines. The Ohio Injector Co.

246 Steel Gate Valves — Four types of Hancock general purpose steel gate valves for process and power piping systems are described in illustrated Bulletin 202 C, 12 pp. Material specifications, dimensions given, also service pressure ratings. Manning, Maxwell & Moore, Inc.

247 General Service Valves — Bulletin E-160, 16 pp, describes and illustrates design and construction of company's quick-operating valves, explaining their application to blow-off service and on chemical process, soot blowers, water column blow-down, and other types of pipe line. Everlasting Valve Co.

248 Regulating Valves — Bulletin 5305 describes double seated diaphragm regulating valves for use with control instruments, outlining special features of the valves, particularly the "flow line" contoured-body engineered for high capacity at low pressure drop. Leslie Co.

249 Pump Valves — Sixteen-pp Catalog SC-510, now available to power engineers, describes and illustrates valves made to fit practically all makes of reciprocating pumps. Key features of the valves are discussed, and standard, lock-in and deck types are covered in detail. Sims Pump Valve Co., Inc.

250 Valve Charts — Now available to power engineers are three well-organized wall charts on valve types, selection and protection. "How to know valves" covers four main types of valves from the standpoints of their appearance, inside construction, service intended, operation and use. "How to select valves" discusses five major factors involved in the choice of a valve — fluid, temperature, pressure, size, and function. "How to protect valves" — written in "do and don't" style — covers 11 important points in valve installation, operation and maintenance. R-P & C Valve Div., American Chain & Cable Co., Inc.

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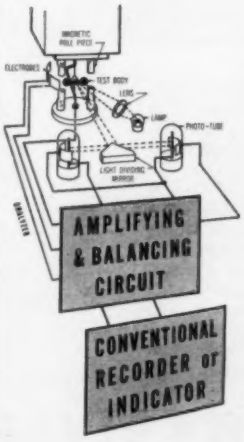

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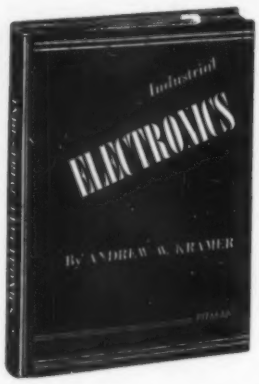

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251 Steam Trap Book — Catalog J, 44 pp, serves as a manual of trapping practice. Includes a catalog section giving physical data and prices on cast semi-steel and forged steel inverted bucket steam traps, compound steam traps and ball float air and air relief traps; a handbook section explaining how to calculate condensate loads and select traps for all classes of equipment; a maintenance section explaining trap installation, trouble-shooting and repair. Armstrong Machine Works.

252 Steam Trap Solutions — Bulletin F. 151, 36 pp, is a newly revised edition of this company's well known booklet, "Solving Steam Trap Problems." Organized for easy reference, this illustrated booklet provides specifications and capacities of steam and float traps, air release valves, pipe line strainers. Tells how to calculate condensation loads and select traps for unit heaters, jacketed kettles, submerged surfaces. Gives tips on installing, servicing. The V. D. Anderson Co.

253 Unions and Fittings — Twelve-pp Catalog 50 covers manufacturer's line of unions of all types, elbows, tees and fittings. It describes and illustrates special features. Dart Union Co.

254 Expansion Joints — Rubber expansion joints for relieving strains and stresses in piping, absorbing vibration, and eliminating noise are the subject of 8-pp Form AD-137. General advantages of rubber expansion joints are presented, and spool-type, U-type and rectangular-type joints are described as to construction and intended services. Also provided is catalog sheet on all-Teflon joints and Teflon-lined rubber joints. The Garlock Packing Co.

255 Asbestos-Cement Pipe — Manufacturing methods in producing asbestos-cement pipe for water systems are described in this 8-pp bulletin, which points out savings in installation time and outlines characteristic advantages once the pipe is in the ground. Recommended procedures for installing pipe and assembling Ring-Tite coupling, as well as table of sizes and fittings are included. Johns-Manville.

255 Stainless Steel Pipe Fittings — Bulletin S-3-55 describes company's 150 lb stainless steel pipe fittings for corrosive, high and low temperature service, including 90 deg elbows, tees, 45 deg elbows, crosses, couplings, reducers, pipe caps, unions, plugs and bushings. Presents dimensional specifications in sizes ⅛ to 2 in. in both screw end and socket welding types. Applications in chemical plants, refrigeration service, food and other process piping given. Watson-Stillman Fittings Div., H. K. Porter Co., Inc.

WATER CONDITIONING

258 What's What on Ion Exchangers — Here are three booklets on ion exchangers: Nalcite HCR, a styrene type cation exchanger; Nalcite SAR, a strongly basic anion exchanger; and Super Nalcolite, a synthetic gel type zeolite for cation exchange. Tables and graphs explain performance of these water treating resins under various operating conditions. Physical characteristics, exchange capacities, regeneration techniques discussed. Bulletin 57, 20 pp, is on Nalcite SAR; Bulletin 58, 28 pp, Nalcite HCR; Bulletin 59, Super Nalcolite. National Aluminate Corp.

259 Handbook on Demineralizing — Comprehensive 40-pp Bulletin 5800-B

compares various methods of water treatment, indicating the comparison between demineralizers and evaporators. It discusses the characteristics of the various types of available cation and anion exchange materials and offers data on operating costs of demineralizing. It tells when to use 2-bed, 3-bed, 4-bed, mixed or monobed demineralizers. It also indicates when decarbonators or vacuum deaerators should be installed. Cochrane Corp.

260 Feedwater Treating — Bulletin 1855, 30 pp, features manufacturer's hot process Accelerator for treatment of boiler feedwater, illustrating and explaining its operation and advantages, also optional equipment. Contains excellent discussion of necessity for treatment of makeup water, selection of proper equipment. Also covers the limitations of hot process softening. Infilco Inc.

261 Steam System Treatment — This bulletin on Coravol for prevention of corrosion explains theory of corrosion, application of organic amines to steam systems (Coravol process) and presents case histories of use in different types of plants and industries. Coravol is part of a complete technical service providing chemical formulas for treatment of water, steam, brine, fuel. Western Chemical Co.

262 On Cooling Tower Wood — The protection of cooling tower wood is the subject of Technical Paper 130. Explains how chemical and bacteriological attack can be controlled by acid treatment and wood preservatives to kill fungi. W. H. & L. D. Betz.

263 Water Treatment — Bulletin 5000, 24 pp, explains the reasons for boiler water treatment and tells services offered by company in providing formulations for individual plant requirements. Covers pretreatment, internal treatment, treatment application, blow-down adjustment, test control. Dearborn Chemical Co.

264 Water Conditioning Data Book — An excellent reference volume, Data Book 2478A contains 108 pp and presents a compilation of 78 chapters and tables. Subjects covered include hydraulics; impurities in water; chemical conversions; coagulant, acid and alkali dosages; chemicals used in water treatment; water treatment processes; boiler feed make-up requirements; alkalinity relationships; specific gravities; chemical reactions. Available to qualified power engineers, please state your job title when requesting this. The Permutit Co.

265 Microbiological Control — Technical Article 3C, 12 pp, is an illustrated discussion of microbiological control of and through industrial waters. A section on industrial water chlorination covers cooling waters and process waters. Other sections deal with chlorine metering in chemical processes, and the sanitary aspects of industrial water treatment. Wallace & Tiernan Co., Inc.

266 Demineralizers — Valuable information on demineralization is offered power engineers in comprehensive 24-pp Bulletin WC-111. Discusses demineralization in general and its advantages and applications. Basic types of demineralizers and their special uses are charted. Resins, piping, valves and accessory equipment are treated in detail. Book also provides flow charts showing demineralization systems for chemical plants and power plants. Graver Water Conditioning Co.

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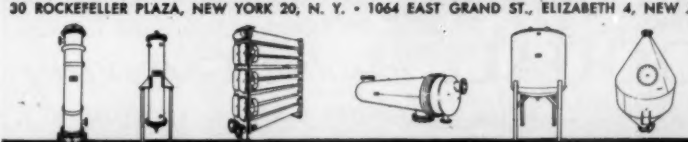

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267 Corrosion Treatment — "Corrosion Protection of Steam and Condensate Return Systems" is a folder on amine treatment for boiler and condensate systems. This treatment is described as affording surface protection of the metal as well as raising pH value of condensate. The Bird-Archer Co.

268 For Industrial Water Softening — Greensand, zeolite and resinous exchange water softeners are described in 8-pp Form S-105. Discusses features and applications of each of these basic types and illustrates some installations. Includes capacity data and general specifications. Illinois Water Treatment Co.

269 For Water Wells — An acidizing service for water wells, designed to increase water yield by enlarging formation channels and by removing scale deposits from pumps and screens, is described in this folder. Lists advantages. Dowell Inc.

FUELS, LUBRICATING OILS

271 Versatile Industrial Oil — Described in 20-pp Form AD 4078 is an all-purpose oil offering protection for a wide range of industrial equipment, and available in 15 viscosity grades. Discusses six major characteristics of the oil; explains and pictures its use in hydraulic systems, speed reducers, air compressors, electric motors, hydraulic turbines, bearing systems, etc. A chart shows grades available, their uses and physical properties. Standard Oil Co. (Ind.)

272 Bearing Lubrication — Vol. XL, No. 10 of this company's Lubrication magazine provides an excellent 12-pp article on industrial bearing lubrication. Illustrated with photos and drawings, text covers such subjects as bearing design; bearing surfaces; bearing overhaul; aspects of lubrication, including factors involved in choice of turbine oils and diesel lubricants, and the deleterious effects of moisture; and the life expectancy of bearing lubricants. The Texas Co.

INSULATIONS

273 Data on Insulations — Insulation solutions for a wide range of temperature problems are charted in this folder. Provides brief descriptive information and tells forms available for high temperature applications, for intermediate temperature use, for hot and cold water and low pressure steam, for ice water and frigid temperatures. Mundet Cork Corp.

274 Pipe-Insulation — Mono-Kover, a lightweight one-piece pipe insulation, is described in this bulletin. Photos show how easily it is applied, and text covers its thermal resistance, permanence, resiliency, non-corrosive properties and lower applied cost. Also included are a thermal efficiency chart, insulation thickness selection table, and information on sizes and thicknesses available in this material. Baldwin-Hill Co.

OTHER EQUIPMENT

275 Steam Accumulator — How the steam supply and demand can be balanced by means of company's steam accumulator is told in Bulletin RA-52-8. Stresses reduced boiler capacity required and increased boiler efficiency afforded by use of the accumulator, other advantages. Discusses operating principle, tells how to figure capacity. Foster Wheeler Corp.

276 Refrigerator Condensers — Bulletin RC-2, 38 pp, utilizes drawings, tables and engineering data to show how to select proper type from company's line of ammonia and Freon condensers for refrigeration services. Illustrates horizontal multipass shell and tube types; vertical singlepass shell and tube types. Gives pipe sizes for ammonia and Freon lines. Henry Vogt Machine Co.

277 Turbine Speed Control — Thirty-pp wire-bound Bulletin H-21 is titled, "Fundamentals of Turbine Speed Control." It is an elaborately illustrated, educational booklet intended to clarify the operation of common types of automatic speed control for steam turbines. An introductory section covers general fundamentals of automatic control systems, and includes a key to control terminology. Simplified diagrams show operating principles of actual control systems. Elliott Co.

278 For Climate Control — Bulletin 122, 8 pp, introduces an air conditioner designed for precise and economical control of air temperature and moisture. Illustrates design of the new machine, tells its features, and pictures some installations. Tells how it is used in heating and cooling processes. Niagara Blower Co.

279 Preheating Combustion Air — This well-illustrated 36-pp booklet explains fuel savings and increased performance made possible by using waste heat in flue gases to preheat incoming combustion air. Also covers increased boiler output, ability to use lower grade fuels, other advantages afforded. Booklet contrasts regenerative with recuperative preheaters; explains op-

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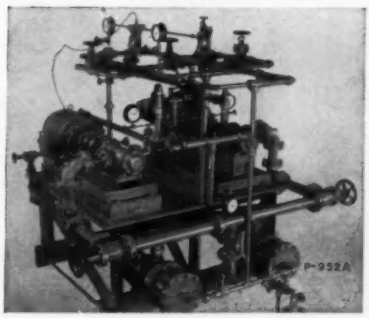

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erating principle and structural details of the Ljungstrom air preheater. Applications for other than power boilers are also covered. Air Preheater Corp.

280 Heat Transfer Apparatus — Condensed Bulletin HT-1 highlights representative products in company's line of heat transfer equipment. Includes oil heaters and coolers, strainers, evaporators, heat exchangers, radiafin air coolers, tubes, pipes, and coils. Schutte and Koerting Co.

281 Conveyor Belt Chart — Engineering data for standard conveyor belt constructions is given in this chart and accompanying sheet. Strength characteristics of eight popular ply and material combinations of conveyor belt constructions are provided. Each property is printed on the chart in a different color to facilitate comparison. Quaker Rubber Corp., Div., H. K. Porter Co., Inc.

282 Fluid Drives — Bulletins 9419 and 9519 are an illustrated catalog and selection guide on company's new Type VS Class 2 Gyrol fluid drives. Catalog discusses advantages and applications of the drives, covering speed control, power savings, simplified installation, etc. A sectional view shows construction and principle of operation. Dimensions for six sizes of drives are provided. Selection guide consists of tables indicating proper drive to use with motors from 7.5 to 800 hp. Separate tables cover variable and constant torque loads. American Blower Corp.

283 Corrosion, Abrasion Control — Modern practices and products for the positive protection of metal equipment from the effects of corrosion and abrasion are described in this 16-pp bulletin. Covers factory and field application of rubber or synthetic linings to metal parts or products, and maintenance coatings available for application by plant personnel. Also gives detailed information on accelerators, thinners, primers. Goodall Rubber Co.

284 Steam Condensers — Some recent additions to this company's power plant condenser installations are pictured and described briefly in this 24-pp booklet. Also included are an engineering section on condenser design factors, and sections devoted to air removal equipment, to steam condenser specialties, and to maintenance services available. Condenser Service & Engineering Co., Inc.

285 Dust Collection — Aerodyne dust collectors in chemical processing and other industries are discussed in 8-pp Bulletin 171. Explains theory and design of collector system, includes drawings of the various types covered. The Green Fuel Economizer Co., Inc.

286 Steam Turbines — The advantages of company's solid wheel turbines, axial flow turbines, single stage and multistage, are outlined in illustrated Bulletin S-140. Describes various models in their line and includes application photos. The Terry Steam Co.

287 Refractory Concrete — Basic information on recommended practice for mixing and placing refractory concrete, used in the metal, power, ceramic, and petroleum refining industry as a material to withstand service temp to 2600 F or more, is presented in this 16-pp manual. Sections are devoted to special properties of refractory concrete, aggregates, refractory insulating concrete, and structural design. Charts and tables afford easy reference. Universal Atlas Cement Co.

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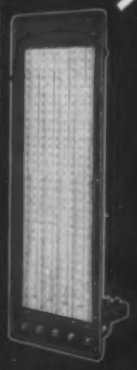

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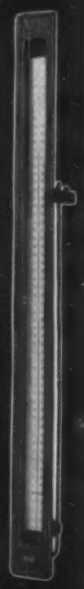

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Engineering Books

Industrial Power Systems Handbook, Donald Beeman, Editor. Size 6½ by 9¼ in., 971 pages, 515 illustrations, cloth. Published by McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y. Price $12.50.

The engineering knowledge required to maintain and operate industrial power generation transmission and distribution systems has increased many fold since electricity was first used. Many industrial power distribution practices have changed so much that they have been almost completely revolutionized. This book outlines up-to-date industrial power system engineering practices which should be especially valuable to industrial plant engineers and electricians, utility power salesmen, consulting engineers, contractors, industrial power application engineers, architects, and others who have anything to do with the planning of electrical facilities for industrial plants or commercial buildings. College professors and students should find it useful for teaching and studying the principles of industrial power system engineering. Although the problems in electric utility generation, transmission, and distribution systems are different in many ways from those in industrial power systems, the utility engineer will find much of the data in this book useful to him, particularly when designing power services for industrial plants.

The book is a compendium of 17 separate chapters, each contributed by a General Electric engineer who is an expert in his subject. The chapter titles are as follows:

1. Short-circuit-current calculating procedures.
2. Symmetrical components as applied to short-circuit-current calculation on three-phase systems.
3. Selection of a-c short-circuit protective devices and circuit equipment.
4. Voltage — standard ratings, allowable variations, reduction of variations, calculation of drops.
5. System overvoltages — causes and protective measures.
6. System grounding.
7. Equipment grounding.
8. Power-factor improvement.
9. System overcurrent protection.
10. Selection of system voltages.
11. Load-center power systems and circuit arrangements.
12. Secondary distribution systems.
13. Primary distribution systems.
14. Power systems for commefcial buildings.
15. Modernization and expansion of existing power systems.
16. Steam and power generation.
17. Load and cost estimating data.

* * *

Storage Batteries, Fourth Edition, by George Wood Vinal. Cloth binding; size 9½ by 6¼ in.; 446 pages. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. Price $10.00.

This is the fourth edition of an already well-known textbook first published in 1924 and previously republished in 1930 and 1940. The new edition has been prepared to include all the many technical advances in design and construction of storage batteries that have taken place in the last 14 years.

As in the previous editions, the book emphasizes the scientific principles of storage batteries without allowing the treatment to become too highly technical. Manufacturing materials and methods are described, and then the operating principles for all the commonly used types of storage batteries are explained in detail.

The author has selected for reference the most valuable papers from the widely scattered literature in this country and abroad, and nearly half the illustrations in this edition are new.

New information in this latest edition covers the following subjects: improved lead alloys to withstand corrosion; increased use of lead calcium alloys; increased use of uncalcined high-metallic oxides; intensive studies of expanders; many new types of separators; increased use of plastic containers; production of nickel-cadmium batteries in the United States; new types of silver oxide cells; application of batteries to radio-relay stations for long distance telephony; battery installations for Diesel starting on railway

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locomotives; introduction of 12-volt systems for automobile starting, lighting, and ignition; 24-volt and higher voltages for use of airplanes, and many other important topics.

The author is eminently qualified in his subject, having been Chief of the Section of Electrochemistry of the National Bureau of Standards for 32 years. He has published many technical papers, both by the National Bureau of Standards and various scientific journals.

★ ★ ★

Applied Solar Energy Research, edited by E. J. Burda, 298 pages; size 5½ by 8½; published by Stanford Research Institute for the Association for Applied Solar Energy, Suite 204, Mayer-Heard Building, Phoenix, Arizona. Price $5.00 (cloth bound) or $4.00 (paper bound).

If you have an academic interest in solar energy development or have research programs in that field, this book can save you much time and effort. It is also a storehouse of ideas presented in a very concise manner. Basically, it is a bibliography and directory of applied solar energy research, a directory of research centers devoted to solar energy studies, and an alphabetical index of individuals engaged in solar research.

This directory does not limit itself to the activities in any one country. Solar energy research has been carried on in 27 countries to this time, and the activities of all these are cataloged herein. As in the dictionary, the plot is somewhat disconnected, but to men interested in solar research it is an excellent investment. Much of the work done thus far by such widely scattered groups has necessarily resulted in duplication of effort and the needless expenditure of funds. We believe the young Association for Applied Solar Energy has performed a real service in backing such an ambitious project at a time when many new research programs are developing.

★ ★ ★

Consulting Services, 15th edition; 144 pages; size 6 by 9 in., paper cover. Published by Association of Consulting Chemists & Chemical Engineers, Inc., 50 East 41st Street, New York 17, New York. Price $1.00.

When you need a consultant, it is a little annoying to have to resort to the yellow pages in the local 'phone book. Such listings carry no qualifications, no background, and frequently carry rather optimistic evaluations of the individual who paid for the ad. This book, and the preceding fourteen editions, were conceived to help you locate a properly qualified consultant in the specialized field of your specific problem. The book is arranged to include a table of contents, a classifier (which identifies available consultants by their specialties), "scope pages" (which describe each member's qualifications and activities), and an index. Members and their geographical locations and organizations to which they belong are indexed in the back of the book. The classifier, for example, will help you locate consultants who specialize or have qualifications in the field of abrasives, air conditioning, ceramics, pH control, or x-rayed fraction analysis.

Rather than pick a consultant blind, or rely on the rather limited experience of acquaintances, it would seem much more advisable to invest $1.00 in this book and do some selective shopping in advance of your actual need for consultants in the chemical field.

★ ★ ★

Compressed Air Handbook (Second Edition), prepared by Compressed Air and Gas Institute. Size 6 by 9 in., 384 pages, illustrated, cloth binding. Published by McGraw-Hill Book Co., 327 W. 41st St., New York 36, N. Y. Price $8.00.

This is a comprehensive, practical guidebook giving descriptions, data, and pointers for achieving the best results with air-powered equipment in all types of industry. It covers the theory, installation, selection, maintenance, and testing of equipment as well as its application.

This second edition contains almost double the number of illustrations in the previous printing, and includes an entirely new chapter devoted to centrifugal compressors. Also new is the latest information on uses of compressed air power, developments in displacement-type compressors, and improved maintenance techniques.

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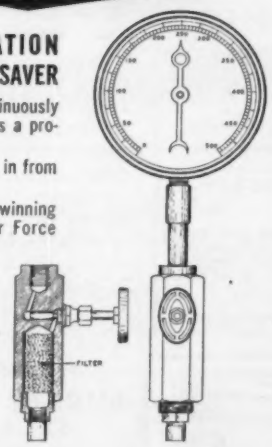

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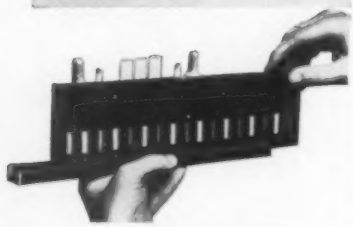

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EQUIPMENT NEWS

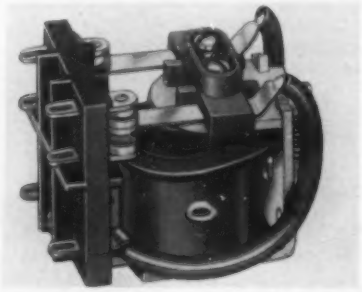
continued from page 48

33—CENTRIFUGAL PUMP for paper stock, other liquids

Classed as a paper stock and industrial liquids pump, this unit has a diverging type impeller which lets the pump handle liquids containing high concentrations of solids, air and gases. This impeller has a much greater area at the discharge than at the inlet, and, according to manufacturer, this design prevents vapor binding, avoids clogging, and makes the pump self-venting and self-regulating. The pump is a horizontal, single-stage centrifugal unit in sizes from 4 to 12 in., with capacities from 200 to 7000 gpm and heads from 5 to 225 ft. Form 7325 gives information on applications. Ingersoll-Rand Co.

34—MIDGET RELAY is rugged and compact unit

Announced as a rugged midget relay that incorporates power capacity and multiple contact combinations in extremely small space, the Series 1200 a-c



or d-c relay is rated up to 8-amp, at 115-v, 60-cycle, non-conductive load. Overall dimensions: $1\frac{13}{16}$ in. long, 1 in. wide, $1\frac{1}{4}$ in. high and the relay weighs only 1.9 oz. Contact combinations are available up to three-pole, double throw.

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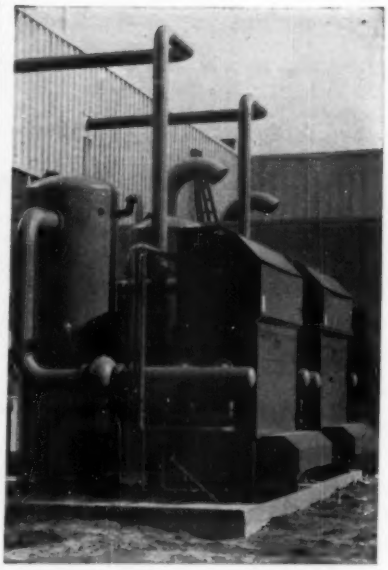

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Equipment may be seen in operation by contacting Mr. Wayne Richardson, Water Superintendent, % Water Works Pumping Station, Belvidere, Illinois.

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Reader Service Cards on pages 121–122 make it easy to get further information on any of these products. Just circle the item numbers of the products you want to know more about.

35—BRONZE VALVES, solder end units, in five types

This line of solder end valves includes three gate valves — rising stem with double-wedge disc, rising stem with solid-wedge disc, and non-rising stem with single-wedge disc — all rated at 125 lb steam pressure and 200 lb WOG. Also available in the same pressure ratings is a swing check valve with renewable disc and side plugs. The line is completed by a non-metallic-disc globe valve, rated at 150 lb steam and 300 lb WOG. The valves embody such features as company's non-slip handwheel, Stemalloy stem, hexagon head gland.

These valves are suggested for use on plumbing, heating, and air conditioning lines; low pressure steam service; underground water lines; condensate return lines; liquor lines in breweries and distilleries. Lunkenheimer Co.

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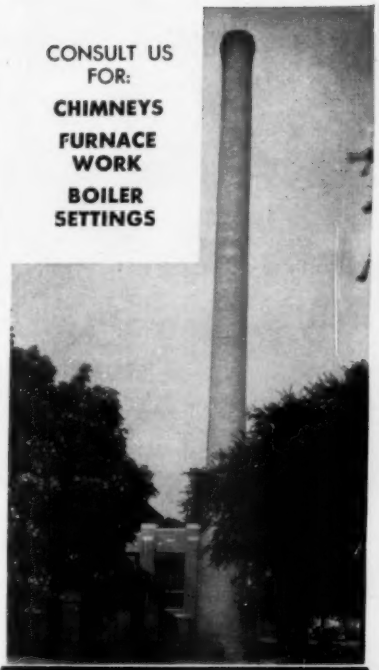

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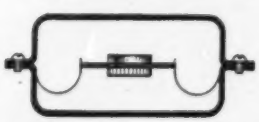
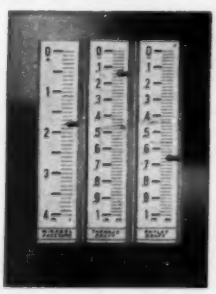
• ELLISON
Straight Line Draft Gage





Special Synthetic Coated Silk Fabric Diafram Lasts for a Generation.

- Non-parallax pointer—always true readings regardless of elevation.
- Translucent ceramic scale—accurate, everlasting.
- Unitized construction—mechanism readily slides out front of case.

Plus 10 Other Features described in Bulletin 124.

ELLISON DRAFT GAGE CO.
550 W. MONROE ST. Since 1896 CHICAGO 6, ILL.

THE ELLISON LINE ALSO INCLUDES:

Draft Gages, Bell and Diafram — Inclined Draft Gages — Portable Inclined Vertical Tube Gages — Vertical Tube Gages — Oil, Heavy Liquid and Mercury — Single and Multi-Tube-Saturator Gages — U Gages — Stationary and Portable — Air Filter Gages — Dial and Inclined Tube Types — Pitot Tubes — U Path Steam Calorimeters — Portable Gas Analyzers-Orsat Type

ELLISON INSTRUMENTS — Outstanding Design, Construction and Accuracy

For more data circle 564 on Post Card

KOR
FUEL OIL CONDITIONER
The Superior Sludge Dispersant Plus a Combustion Catalyst for Treating Residual Fuel Oils, Diesel Oils, and Petroleum Pitch

Gives the Kind of Results You Expect to Get • Greatly Reduces Maintenance Costs • Helps Obtain MORE Steam or MORE Heat with LESS Oil

RUST RESISTANT
NON-CORROSIVE
NON-EXPLOSIVE
Flash Point 165° F.
Fire Point 240° F.

CHEMICALLY STABLE • ACTIVE INGREDIENTS

Send for performance proofs, bulletins, prices

DIRECT FACTORY SERVICE TO INDUSTRY

KOR CORPORATION
Division of Oxi Corporation
600 WEST 9th AVENUE, GARY, INDIANA

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FOR REPLACEMENTS ORDER HIGH PRESSURE

GAGE GLASSES

MAGNIFYING RED LINE

MASTER STANDARD RED LINE & CLEAR
Up to 500 lbs.

MASTER CLEAR & RED LINE EXTRA STRONG
Up to 600 lbs.

Made in Lengths up to 144" Long
And Outside Diameters ⅜", ½", ⅝", ¾", ⅞", 1", 1¼", 1½".

High Pressure Composition
ERNST RUBBER GASKETS
All sizes to fit your gages and valves

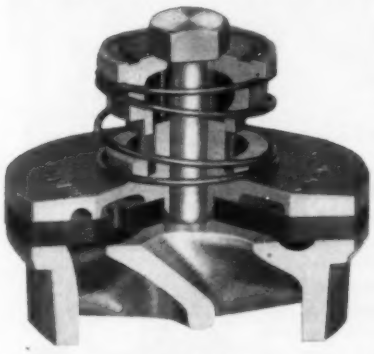
FIG. 21—Lip Mold

FIG. 22—Standard

ERNST WATER COLUMN & GAGE CO.
Send for Catalog LIVINGSTON, N. J.

For more data circle 567 on Post Card

SIMS INCLINED PORT ROTATING PUMP **VALVES**



Guaranteed to:

1. **REDUCE** Seat and Disc Wear.
2. **INCREASE** Pump Capacity.
3. **REDUCE** Maintenance Costs.
4. **WORK** Efficiently in Light or Heavy Liquids.

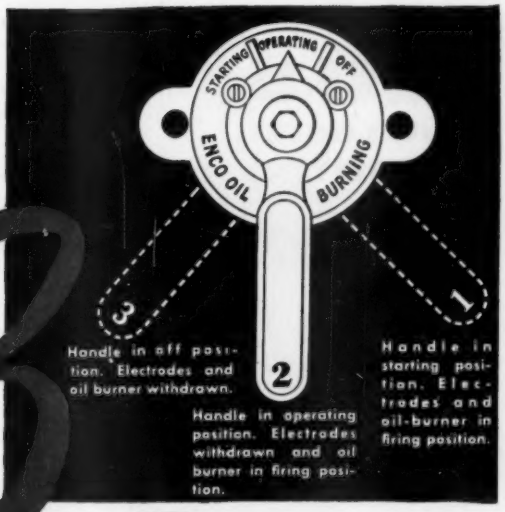
Sims Valves are available for all reciprocating pumps from stock.

Write for New Catalog PE-1

Sims
PUMP VALVE CO., INC.
1314 Park Avenue Hoboken, N. J.

For more data circle 568 on Post Card

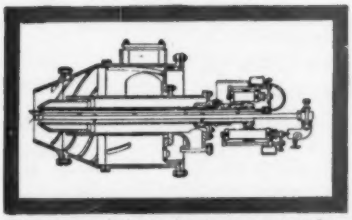
Hand Control Valve for cylinders . . . wall mounting . . . oil burner ignition system.



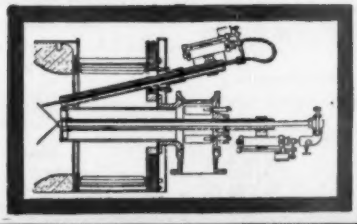
3 Step
IGNITION SYSTEM
FOR PULVERIZED COAL, OIL, OR GAS

FAST
SAFE
POSITIVE

Atomizer and electrodes in the central tube.



Atomizer and electrodes in separate tubes.



With an Enco Ignition System, operator can light off any burner by movement of a Hand Control Valve, located close to the pulverized-coal mill and fan controls, and within view of the instrument board. Automatically, a powerful ignition spark is established, and the light fuel turned on. Both are interlocked electrically — **the oil valve cannot be opened until the spark current is on and the atomizer is in firing position.** After the oil flame is established, a second movement of the control valve retracts the electrodes, leaving the atomizer in operation.

After ignition of the pulverized coal is established, a third movement of the control valve shuts off the oil and retracts the atomizer out of the hot zone, leaving the unit ready to repeat the operation as may be needed.

The Enco Ignition System has a wide range of application. Pulverized coal, blast furnace gas or any liquid fuel may be ignited by the unit, or the spark alone may be used to ignite natural or refinery gas. The ignition flame can be changed gradually from light to heavy fuel oil if continued operation under heavy load is required. The ignition flame also can be used as a substitute for principal fuel in emergencies.

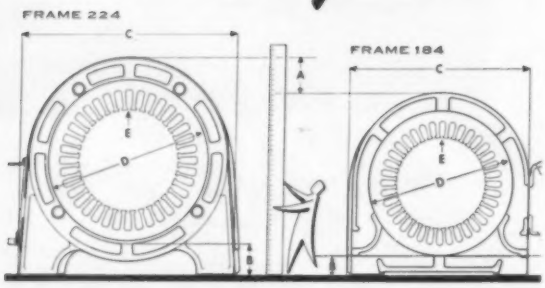
Bulletin on request.

THE ENGINEER COMPANY
75 West Street, New York 6, N. Y.

Enco OIL BURNING EQUIPMENT

For more data circle 569 on Post Card

THE NEW U.S. UNICLOSED MOTOR saves 46% in space*



* EXAMPLE—
2 h.p., 4-pole
Previous 224 Frame—
1663 cu. in.
New 184 Frame—
891 cu. in.
SAVING—
772 cu. in.
or 46%

COMPARISON

A—Over-all height reduced
B—Stator closer to mounting surface
C—Over-all width reduced
D—Approx. same punching O. D.
E—Same number of slots

More Horsepower per cubic inch

Saving in space of 46% for the 2 h.p. size, in comparison with previous NEMA dimensions, is typical of the ratings in the new U. S. Type H Uniclosed motor. Improvement of insulation, advanced electrical design, closer tolerances, all contribute to development of maximum horsepower within the least cubical space. Many other exclusive U. S. features, such as asbestos-protected windings, Lubriflush transverse lubrication, solid cast-iron frame and normalized castings, also add longer life and more efficient power.

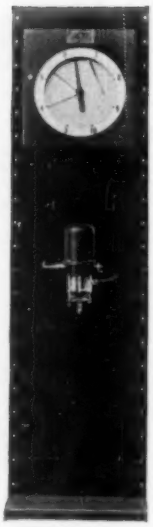
Mail Coupon for informative full-color 12-page Type H Bulletin

U. S. ELECTRICAL MOTORS, INC. PE-1
P.O. Box 2058, Los Angeles 54, Calif., or
Milford, Conn. Send Type H Bulletin No. F-1856

USMOTORS

NAME _____
COMPANY _____
ADDRESS _____
CITY _____ ZONE _____ STATE _____

For more data circle 570 on Post Card



Single-Point pH Recorder (Strip Chart Assemblies also available)

CAMBRIDGE pH INDICATORS and RECORDERS

Labor saving—profit producing!

In addition to portable pH meters, Cambridge makes line-operated Direct Reading pH Indicators and Recorders for permanent installation. They are accurate, stable and assure continuous and trouble-free performance. Either the Recorder, Indicator or both, may be located at any reasonable distance from one or several sampling points. The Glass Electrodes are placed in vapor-tight housings of clog-free sampling chambers.

Send for Bulletin No. 910 T

CAMBRIDGE pH EQUIPMENT

CAMBRIDGE INSTRUMENT CO., INC.
3523 Grand Central Terminal, New York 17

PIONEER MANUFACTURERS OF PRECISION INSTRUMENTS

For more data circle 571 on Post Card

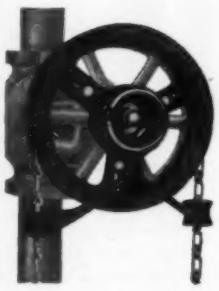
Protect Your Manpower with...

Babbitt *Adjustable* SPROCKET RIM *with Chain Guide*

Control out-of-reach overhead valves right from the floor! No more climbing on ladders, balancing on boilers, perching on workbenches or machines. Prevent accidents and costly claims — also save fuel, steam and money.

Only four simple, quickly-assembled parts installed and operating in only a few minutes, Babbitt Adjustable Sprocket Rim with Chain Guide —

- **Fits all valve wheels**
- **Simplifies pipe layouts**
- **Eliminates risky climbing**



Range of 10 adjustable sizes fits all valve wheels from 2 to 30 inches diameter, with rising or non-rising stems.

Call your Industrial Distributor. He carries complete stocks.

Babbitt STEAM SPECIALTY CO.
4 BABBITT SQUARE, NEW BEDFORD, MASSACHUSETTS

For more data circle 572 on Post Card

Specify CHAPMAN STEEL VALVES

in any of the Standard Alloys

to meet your steel valve needs

When you specify Chapman Steel Valves you also specify steels designed for your specific services. Standard alloy steels match every normal industrial requirement. Special alloys can be furnished for extraordinary service conditions. All metals are poured in Chapman's own foundries under rigid laboratory supervision.

Exceptionally close machining tolerances are another standard feature of Chapman Steel Valves. Under the most severe conditions, Chapman Steel Valves seat tightly and positively, without jamming, chattering, or wearing excessively. Operation remains smooth and dependable; maintenance costs stay low.

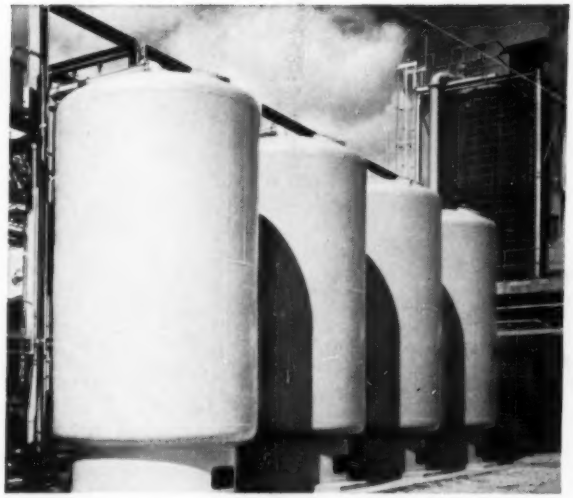
See Chapman *first* for gates, globes and checks in all pressure classes — 150, 300, 400, 600, 900, 1500 and 2500 pounds — and for temperatures to 1150°F. Valves are available with welded, pressure seal, or bolted bonnet joints and with flanged or welding ends. ASA standards are equalled or exceeded in every range. Write for Catalog 20.

THE CHAPMAN VALVE MANUFACTURING COMPANY

INDIAN ORCHARD, MASSACHUSETTS

For more data circle 573 on Post Card

ENGINEERING. Permutit engineers work with your staff or your consulting engineers to design all or any part of your water conditioning system.



EQUIPMENT. Permutit supplies complete equipment. Critical parts such as valves, chemical feeders and controls are designed and made by Permutit.

How Permutit® Solves a Water Problem

U. S. industry is faced with using lower grade water. Results: possible boiler scale, turbine deposits, corrosion of pumps and piping . . . also stains, blisters and other problems in plating, rinsing, dyeing and chemical processing.

• **For expert answers,** more and more management men and their consultants are buying the complete service offered by leading water-conditioning firms. Here's how Permutit (rhymes with "compute it"), a pioneer and largest in the field, tackles a water problem:

• **Water analysis,** study of the problem and past experience provide data on possible methods of treatment. The process offering the best balance of initial and operating cost vs desired quality of treated water is selected.

• **Complete proposal** by Permutit engineers covers type, size and capacity of equipment, price, any special engineering services and performance guarantees.

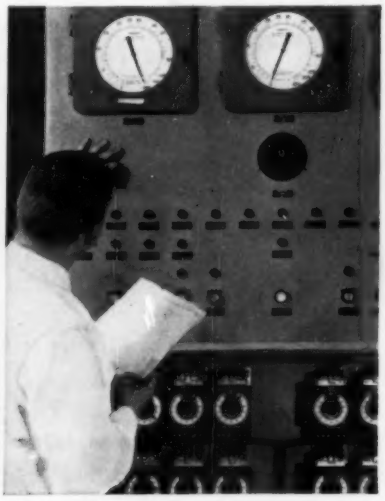
• **Manufacturing** – After the proposal is accepted, Permutit designs the entire project, schedules assembly and shipping. Critical parts, ion exchange resins, control panels are all made in Permutit plants. (No other U. S. firm makes all these components.)

• **Test runs** – Where required, Permutit checks the installation, supervises start-up and initial operation, trains permanent operating personnel.

• **For further information** look up the Permutit office in your city or write to The Permutit Company, Dept. **PE-1,** 330 West 42nd St., New York 36, N. Y.

WATER ANALYSIS. Permutit's modern water-analysis laboratory tests over 1200 samples a month!

ION EXCHANGE RESINS. Permutit makes its own ion exchange resins, natural and synthetic zeolites.



AUTOMATIC CONTROLS to ensure optimum results are designed, assembled, wired and tested by Permutit.

For more data circle 574 on Post Card